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ABSTRACT

This document presents Part I of a two-part study which sought to ascertain the relationship of grade level, achievement level, sex, and method of presentation to the various bases by which children classify geometric concepts. Two tasks, administered consecutively to 96 subjects in grades five, eight and eleven, consisted of the sequential presentation of an array of eight geometric concept cards (Task I), and a 26-item picture array of geometric concept instances presented simultaneously (Task II). Responses for Task I were categorized as: Perceptible, Attribute, Nominal, and Subject-fiat. Responses on Task II were categrozied as: Perceptible, Attribute, and Nominal. Essential findings, which are summarized in Part II, were that an increase in grade level was accompanied by decrease in the use of the Perceptible basis of classification and an increase in the Attribute and Nominal; high achievers used the Perceptible category less and the Attribute and Nominal categories more than low achievers; sex differences were not significant; and subjects who were presented with pictorial stimuli gave more Perceptible responses than those presented with verbal stimuli on Task I. For summary, appendices, and references, see CG 006 041. (Author/CJ)

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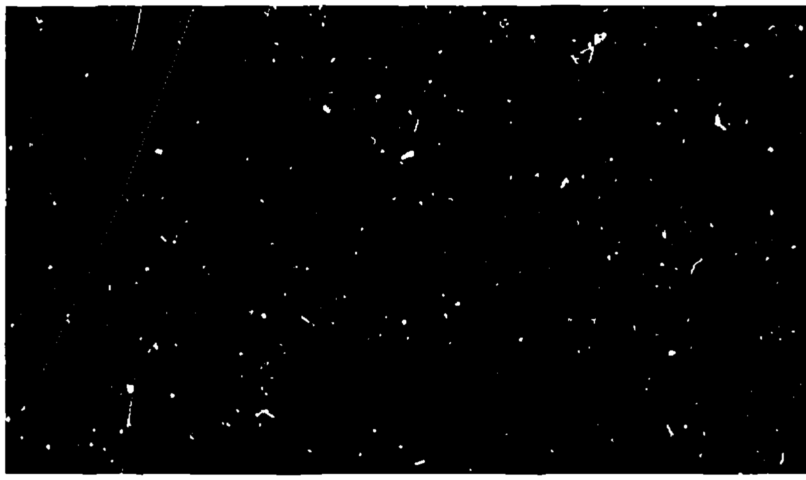

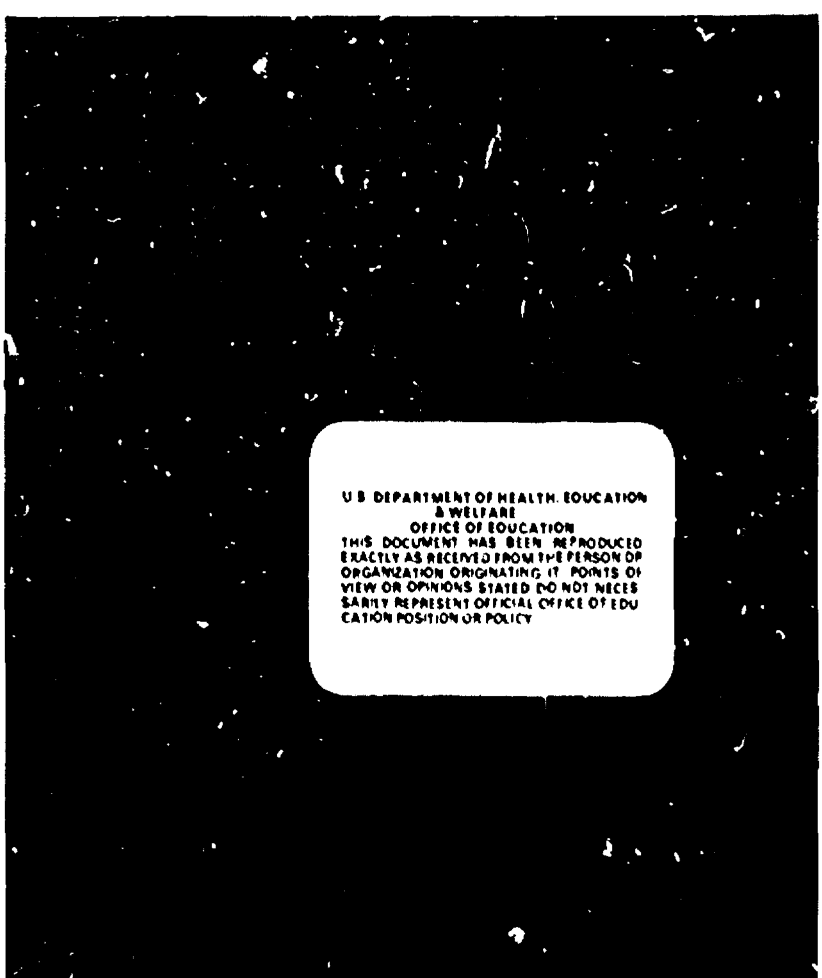

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BASES OF CLASSIFICATION OF GEOMETRIC CONCEPTS USED BY CHILDREN OF VARYING CHARACTERISTICS

Report from the Project on
Situational Variables and Efficiency of
Concept Learning

By Suzanne Pasch Wiviott

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Madison, Wisconsin

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STATEMENT OF FOCUS

The Wisconsin Research and Development Center for Cognitive Learning focuses on contributing to a better understanding of cognitive learning by children and youth and to the improvement of related educational practices. The strategy for research and development is comprehensive. It includes basic research to generate new knowledge about the conditions and processes of learning and about the processes of instruction, and the subsequent development of research-based instructional materials, many of which are designed for use by teachers and others for use by students. These materials are tested and refined in school settings. Throughout these operations behavioral scientists, curriculum experts, academic scholars, and school people interact, insuring that the results of Center activities are based soundly on knowledge of subject matter and cognitive learning and that they are applied to the improvement of educational practice.

This technical report is from the Situational Variables and Efficiency of Concept Learning Project in Program 1. General objectives of the Program are to generate new knowledge about concept learning and cognitive skills, to synthesize existing knowledge, and to develop educational materials suggested by the prior activities. Contributing to these Program objectives, the Concept Learning Project has the following five objectives: to identify the conditions that facilitate concept learning in the school setting and to describe their management, to develop and validate a schema for evaluating the student's level of concept understanding, to develop and validate a model of cognitive processes in concept learning, to generate knowledge concerning the semantic components of concept learning, and to identify conditions associated with motivation for school learning and to describe their management.

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And last, but most importantly, I want to express my gratitude to my husband, James. Without having the confidence in himself that allowed me to pursue my aspirations and the confidence in me that helped me adhere to my goal, I would never have been able to succeed.

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ABSTRACT

The purpose of this experiment was to ascertain the relationship of grade level, achievement level, sex, and method of presentation to the various bases by which children classify geometric concepts.

Two tasks were administered consecutively to 96 subjects in the fifth-, eighth-, and eleventh grades, 32 at each grade level. The subjects were randomly selected from groups stratified according to sex and mathematical achievement level and then randomly assigned to either the verbal or pictorial treatment group for the first task.

Task I consisted of the sequential presentation of an array of eight geometric concept cards. The concepts were progressively more diverse and the final concept was a contrast class. The array consisted of square, rectangle, rhombus, parallelogram, quadrilateral, triangle, circle, and cube. The subjects were presented with the first two items and asked how they were alike. The third item was then presented and the subjects asked how it differed from the first two and then how all three were alike. The procedure was continued until all the items except "cube" had been included in a similarity formation. Half the subjects saw cards with the concept name printed on them; the remaining half saw cards with the concept instance printed on them.

In the second task, a 26-item picture array of geometric concept instances was simultaneously presented. The concepts were those used in Task I although the contrast item, "cube," was eliminated. Instances of the seven geometric concepts were varied along the irrelevant attributes of size and orientation. The subjects were asked to form a group of instances that were alike and then explain how they were alike. The instances were replaced in the array and the procedure continued until seven different groups had been formed.

Responses given by subjects on Task I were categorized according to four bases of classification: Perceptible, Attribute, Nominal, and Subject-Fiat. Responses given by subjects on Task II were categorized according to three bases of classification: Perceptible, Attribute, and Nominal. The essential findings were:

1. An increase in grade level was accompanied by a decrease in the use of the Perceptible basis of classification and an increase in the attribute and nominal bases of classification. Thus, the development of classificatory behavior proceeds with age and experience from reliance on perceptual cues toward the use of intrinsic properties.

2. High achievers at all grade levels used the Perceptible category less and the Attribute and Nominal categories more than low achievers. High achievers thus appear to develop more rapidly the ability to classify by means of intrinsic characteristics.

3. Boys and girls did not differ significantly in their bases of classifying geometric figures.

4. Subjects who were presented with pictorial stimuli gave more Perceptible responses than subjects who were presented with verbal stimuli on Task I. There also appeared to be a tendency for subjects who had received words as stimuli on Task I to give more Nominal responses on Task II than subjects who had received pictures as stimuli on Task I.

Chapter I

INTRODUCTION

The resurgence of interest in cognitive processes and cognitive development during the last fifteen years is reflected in the increased attention psychologists have given to the acquisition of cognitive skills in children. A comprehensive research and development program designed to identify the cognitive operations involved in concept learning and the variables which may facilitate this learning is underway at the Wisconsin Research and Development Center for Cognitive Learning. Attention is focused on the extension of concept learning research into the real world of the classroom. This study was designed to fit into this program of research by helping to clarify the bases by which school children classify concepts. It attempts to delineate the changes which occur with age in the classification of one kind of concepts, namely geometric figures.

The present study of classificatory behavior was designed as a replication of the work of Jerome S. Bruner and his co-workers on classificatory behavior (Bruner, Olver, & Greenfield, 1966). It was hoped that this study could extend the conclusions of the Bruner studies to the classroom setting. Bruner's cognitive theory envisions cognitive growth as the development of increasingly powerful representational systems for dealing with future encounters of the organism with reality. This viewpoint will be examined briefly in order to provide background for Bruner's work on classification as a manifestation of cognitive growth.

The theory of cognitive growth that Bruner presents in his book, Studies of Cognitive Growth, (Bruner, Olver, & Greenfield, 1966) is a theory that explains cognitive learning in terms of the internal representations of experiences. Three major themes are essential to the order of growth that Bruner describes. One theme he deals with is the impact of culture on the growth of cognitive abilities. Another relates man's growth to his evolutionary background. These are not of importance to the present study. The theme which is most relevant deals with the ways in which people represent their experience and how they organize for future use the experiences they have had. Bruner postulated significant changes in how the individual represents his experiences internally and also in how he acts upon the environment. The two are closely related.

The first type of representation used by children is what Bruner labels the "enactive" mode of representation. Bruner suggests that the very young child first knows the world by the actions he uses to deal with it. In the course of development the child must first get the world of vision in correspondence with the world of action, and then later, free the perceptual world from the world of action. When a child is able to represent the world by an image which is relatively free of action, he is usin~ the "ikonic" mode of representation. This occurs early in the second year of life.

Since it is difficult to infer the nature of the images which children use to organize their cognitive activity, Bruner begins by discussing the organization of perception in the young child. He suggests that the properties of perception might appear in the child's imagery. As Bruner says:

> . . . perception in young children can be characterized by the following features, according to Gibson and Olum (1960): 1) it is "stuck" or nontransformable; 2) it is "autistic" or subject to the influence of affect; 3) it is "diffuse" in organization; 4) it is "dynamic" in the sense of being closely related to action; 5) it is "concrete" rather than schematic or abstracted; 6) it is "egocentric" in the sense of having a central reference to the child as observer; and 7) it is marked by an unsteady attention. To this interesting list we would add one more entry: 8) the young child's perception is organized around a minimal number of cues, and these cues are usually the ones to which the child can most readily point. [Bruner, et al., 1966, p. 21]

These characteristics of early childhood perception suggest a system that is highly uneconomical. Bruner points out that it is as if the child, having achieved a perceptual world that is not directly linked to action, deals with only the surface of things that attract his attention rather than with the deeper structures based on invariant features.

The next step in his cognitive development comes with the development of "symbolic" representation where the child needs to find a way to get to the base structures of the world of appearance. While younger children use surface cues and fail to solve problems, the older child succeeds by responding to "invisible" features such as hierarchies and relations. Bruner sums up his discussion of symbolic representation in the following way:

> . . . symbolic activity stems from some primitive or protosymbolic system that is species-specific to man. This system becomes specialized in expression in various domains of the life of a human being: in language, in tool-using, in various atemporally organized and skilled forms of serial behavior, and in the organization of experience itself. We have suggested some minimum properties of such a symbolic system: categoriality, hierarchy, predication, causation, and modification. We have suggested that any symbolic activity, and especially language, is logically and empirically unthinkable without these properties. [Bruner, et al., 1966, p. 47]

Thus, representation can be accomplished in the media of symbols, images, and actions. The three systems are parallel and each is unique but they are capable of partial translation into each other. Bruner suggests that this disequilibrium between the systems of representation is an important impulsion to cognitive growth. It is when systems of representation come into conflict that the child makes revisions in his method of solving problems.

Thus, there are three modes of interacting with the environment and also three modes of internal representation: enactive, ikonic, and symbolic. The very young child represents or "knows" by doing. As he matures he becomes able to depict his experiences in language.

Bruner postualtes stages in the development of thought. He sees the child as proceeding from dealing with things one at a time in terms of their perceptual appearances to dealing with sets of invariable features several at a time and in some structural relationship. The development of classificatory behavior mirrors these changes and becomes an important area of investigation to Bruner. A brief overview of Bruner's theory of classificatory behavior follows. According to Bruner:

> This course of growth by which finally all three techniques of knowing come into force--enactive, ikonic, and symbolic representations--is reflected in the changing ways that children have for imposing equivalence on the things of their world. [Bruner, et al., 1966, p. 68]

Each type of representation might be hypothesized to emphasize different features of the environment as the basis of classification. Bruner theorized, then, that with enactive representation things might be considered alike to the extent that likenesses are experienced through actions on the objects. Under ikonic representation things should be considered the same to the extent that likenesses are observed perceptually. With the achievement of symbolic representation, classification might be expected to take on the form of the conventional categorization and hierarchical organization that is used in language.

Bruner's discussion of classificatory behavior sets forth a valuable theoretical foundation of the developmental nature of the bases of classification. With the addition of variables concerned with the effect of subject characteristics and the effects of different types of materials on the growth trends discussed by Bruner, more information might be obtained to provide implications for education about the development of this cognitive skill.

The purpose of this study was to ascertain the relationship of method of presentation, grade level, achievement level, and sex to the various bases by which students classify geometric concepts. The specific questions which the experiment sought to answer were:

1. Do children in grades 5, 8, and 11 differ in their bases of classifying geometric figures?

2. Do children of high and low mathematical achievement level differ in their bases of classifying geometric figures?
3. Do boys and girls differ in their bases of classifying geometric figures?
4. Do verbal and pictorial presentations result in differing bases of classifying geometric figures?
5. Does the percentage of correct classifications differ between grade levels, achievement levels, sexes, and methods of presentation?

Geometric concepts were selected because of their explicit definition and their similarity to concepts actually taught in the classroom. It was reasonable to suspect that a list of concepts closely allied to those taught in school might provide information on how children categorize concepts that are presented to them in the course of classroom instruction.

Examination of the five questions posed in the study provides rationale for the research which purports to extend to the classroom the developmental studies of classificatory behavior performed by Bruner and his co-workers (Bruner, et al., 1966). The first question is most clearly related to the developmental theory of classification presented by Bruner in that it was intended to discover whether the growth trends in classificatory behavior postulated by Bruner would appear when geometric figures were used as materials.

The second question was designed to explore the effect of achievement level on the bases of classification. The Ss in the Bruner studies (Bruner, et al., 1966) were in the upper intelligence range. While there was no reason to suspect that lower-achieving Ss could not classify the concepts, it was hypothesized that the bases of classification they used would reflect differences in their pattern of development.

The third question deals with the effect of the sex. Inasmuch as males generally perform better in mathematics than females, it was hypothesized that males would give a relatively higher percentage of responses dealing with the attributes and hierarchical classification of the concepts and a relatively lower percentage of responses involving perceptible bases of classification.

The fourth question concerns the verbal or pictorial method of presentation of the concepts. In the verbal method, Ss were shown a concept name which was pronounced for them; in the pictorial method, the Ss were shown only a concept instance with no name given. The use of geometric concepts precluded using only the verbal method of presentation since the lack of familiarity with the concept names might put the younger Ss at a disadvantage. It was thus hypothesized that the Ss in the younger grades would be able to classify the figures more easily when the pictorial stimuli were used, since their responses would not depend on their knowledge of the concept name. With an increase in age little difference between verbal and pictorial presentations should be evident, for with increased familiarity with the concept name the difficulty of the verbal presentation should decrease.

The fifth question added yet another possibiltiy for clarifying the bases of classification that children use to categorize. It was possible that a S could state a reason why two objects were alike and yet be incorrect in his perception. It was hypothesized that there would be an increase in the percentage of correct categorizations with age, possibly as a function of instruction or facility with language.

Method

Two tasks designed to determine the bases on which children classify geometric concepts were utilized. The first was a fixed-order sequential array presentation and the second a free-sort simultaneous array presentation.

The Ss were 96 students enrolled in fifth-, eighth-, and eleventh-grades, 32 at each grade level. The Ss were randomly selected from groups stratified according to sex and mathematical achievement level and then randomly assigned to either the verbal or pictorial treatment group for the first task.

The two tasks were administered consecutively to each S in one session. The first task consisted of the sequential presentation of an array of eight geometric concept cards of which the final item was a contrast class. The array consisted of: square, rectangle, rhombus, parallelogram, quadrilateral, triangle, circle, and cube. The S was presented with the first two items and asked to explain how they were alike. The third item was then presented and the S asked how it differed from the first two and then how all three were alike. The procedure was continued until all the items except "cube" had been included in a similarity formation.

In the second task, a 26-picture array of geometric concepts was simultaneouly presented. The concepts were those used in Task 1, although the contrast class item, "cube," was not included. Instances of the seven geometric concepts were varied along the irrelevant attribute dimensions of size and orientation. The S was asked to form a group consisting of instances that were alike and then explain how the instances were alike. The instances were replaced in the array and the procedure continued until seven different groups of instances had been formed. The responses given by Ss on Task I were subsequently categorized according to four bases of classification: Perceptible, Attribute, Nominal, and Subject-Fiat. The responses given by Ss on Task II were categorized according to three bases of classification: Perceptible, Attribute, and Nominal.

The independent variable of method of presentation and the stratifying variables of grade level, achievement level, and sex resulted in a 2x3x2x2 design. Dependent variables employed were the number of initial responses in each classification category on Task I, summed over concepts; the number of initial responses in each category on Task II, summed over the seven sorts; and the percentage of total correct responses on Task I and on Task II. Multivariate analyses of variance on linear combinations of the bases of classification were carried out to determine the effects of grade level, achievement level, sex, and method of presentation.

Significance of the Study

The study of equivalence formation presented in this paper provided additonal information about the developmental nature of this cognitive ability. The illustration of a pattern of growth in the bases used to classify geometric concepts would be a replication of the Bruner formulation.

Also, it is possible to project the feasibility of utilizing an instructional program to bring the younger students' ability to classify things by means of their intrinsic properties to the higher level exhibited by older children. A cognitive ability which appears to develop with age might actually be an achievement which can be taught so that it would reach fruition at an earlier point in the students' development. This would be a valuable tool for the child to use in his classroom learning. The effects of achievement level, sex, and method of presentation on the bases of classification children use to classify geometric concepts might add information on the way in which this instructional program could be implemented.

Chapter 2

REVIEW OF RELATED RESEARCH

Many persons have studied the growth of classification as a manifestation of cognitive growth. A review of this literature comprises the first section of this chapter. These studies suggest the developmental nature of the bases of classification, but do not deal with the effects of subject characteristics and the effects of changes in the nature of the materials on the growth trends reported. Studies falling in the area of the three stratifying variables manipulated in this investigation: grade or age level in cognitive learning, achievement level in cognitive learning, and sex in cognitive learning, will be discussed next. Finally, research related to the effects of pictorial vs. verbal presentation of stimuli will be reviewed.

Studies of Classification

Studies of classification which will be reviewed deal with developmental trends in classificatory behavior. Many are descriptive and indicate only the types of classification used at different age levels. Others are based on the theoretical position set forth by Inhelder and Piaget (1958) and use Piagetian tasks in an effort to replicate or repudiate the results. The Bruner, et al., (1966) studies on the bases of classification which served as an impetus for the research reported in this paper will be presented in detail following the discussion of other studies of classificatory behavior.

Several studies have investigated children's concepts of color, size, and form. Over forty years ago, Brian and Goodenough (1929) investigated children's use of form, color, and size in classifying stimuli into conceptually similar groups. They found that children under three years of age preferred form to color in organizing their world into groupings of similar stimuli. Then, at about age 3, color became predominant and was preferred to form until age 6 when form was again preferred. The proportion of form to color responses increased steadily from age 6 to adulthood.

When preschool children were asked to select objects that belonged together, Lee (1965) similarly found that concepts of color and size were easier to apply than concepts of number and form.

Kagen and Lemkin (1961) examined the tendency of children aged 3-8 to use color, form, or size in their classificatory behavior. They found that all subjects preferred form to color or size and that size was rarely used as a basis of classification. They concluded that young children's understanding of the phrase "same as" is influenced primarily by the shape or form of the stimulus rather than its color or size.

There can be little doubt that a major source of impetus to the study of the acquisition of cognitive skills in children has been the work of Jean Piaget and his colleagues at the International Center of Genetic Epistemology in Geneva. A detailed explanation of the actual steps by which children learn classification is offered by

Inhelder and Piaget in their book, The Growth of Logical Thinking From Childhood to Adolescence (Inhelder and Piaget, 1958).

Development appears to proceed in eleven partially ordered steps. Classification begins when the child groups together two objects that are equivalent because they look alike in some way (resemblance sorting). As the child grows he learns to extend the scope of his groupings from two to more than two objects (exhaustive sorting). The child also learns which are acceptable categories for grouping. Physical proximity becomes a less favored means of categorizing since the resulting groups are transitory (conservation).

Experiments in constructing one class at a time prepare the child for forming classifications and for understanding class inclusion. Slowly the child begins to see that objects can belong in more than one category (multiple class membership), and he tries out different groupings of objects, choosing first one and then another attribute as a basis of grouping (horizontal classification). As his logical abilities develop, his method of choosing criteria become more complex. He chooses single attributes and then combinations of attributes to construct successive classes (hierarchial classification). He can now form classes that stand in an inclusive relationship to each other.

Thus, when the child reaches the level of multiple class membership, he must understand certain rules to proceed to the level of hierarchial classification. These include the meaning of "some" and "all," and the relationships that A and $A' = B$ and $B-A' = A$ and, therefore, that $B > A$. He has now developed his classificatory behavior from a level of action to a perceptual, concrete level to the selection of attributes until he reaches the level of hierarchical classification in adolescence.

A paper by Lovell, Mitchell, and Everett (1962) described an experimental study involving individual testing of children using experiments of the type described by Inhelder and Piaget (1958). The study was designed to analyze the stages through which children pass in classifying objects. The children ranged in age from 5 to 15 years and were presented with tasks which included Piaget's Hierarchical Classification of Animals, Spontaneous Classification of Geometric Shapes, and Visual Classification. The results agreed closely with those of Inhelder and Piaget concerning the movement from resemblance sorting to hierarchical classification, thus confirming many of their predictions by giving a number of tests to the same children.

Kofsky (1966) attempted to test Piaget's hypothesis that there is a fixed order in which classification concepts are acquired. She translated Piaget's eleven rules of classificatory development into eleven experimental tasks devised to test the order of acquisition of classificatory ability ranging from resemblance sorting to hierarchical classification and to determine whether Ss who had mastered a particular rule had also mastered all the simpler prerequisite rules.

Her Ss were 122 children ranging in age from 4-9 who were required to demonstrate understanding of each of the eleven classificatory operations by correctly manipulating a set of geometric blocks varying in shape and color. The data were analyzed to elicit information regarding age differences in classificatory skills and the validity of Piaget's theory. Each S received a score based on the number of tasks he had passed. An analysis of variance showed significant age effects and the correlation of the predicted logical sequence with the obtained sequence of difficulty was .87. The order of difficulty was in the predicted developmental order, but there was no set order of mastery such that children who passed difficult items necessarily passed all earlier items.

Wei (1967) compared the classificatory behavior of socially disadvantaged children with that of middle class children in kindergarten and second grade. He administered four Piagetian tasks to 20 culturally deprived and 20 middle class children at each age level. He found that the ability to classify does increase with age, although the disadvantaged children progress at a slower pace and are less able to give reasons for their classifications. The data thus supports Inhelder and Piaget's theory of a sequential and logical development of classificatory behaivor that is related to chronological age.

Halpern (1965) examined the relationship between thinking dominated by perception and thinking guided by logic within Piaget's theory. She questioned what the effect of perception might be on a deductive task at the level of concrete operations when Ss supposedly no longer relied primarily on perceptual cues. She examined two groups of Ss, one with an empirical outlook and one with a deductive orientation, in a situation where perceptual configurations and logic competed. Her hypotheses were: (1) children with an empirical orientation will err more often than children with a deductive orientation in solving problems that offer both perceptual and logical cues, and (2) children with an empirical outlook will make most of their errors where perception directly contradicts logic. Both hypotheses were confirmed. Thus, logical thinking does not always correct deceptive perceptions, although it may. Even in the presence of operational structures, perceptions can govern thinking. Halpern concluded that while Piaget stresses forward movement, it is possible that a residue of former modes of thinking remains and will be used in a situation where conflicts arise.

Price-Williams (1962) asked Nigerian children in their language to classify certain animals and plants familiar to their primitive society and scored their responses on bases of classification moving from perceptual to attribute responses. He found that little difference existed between the African Ss and European children and suggested this was evidence of a cross-cultural fit of Inhelder and Piaget's framework.

In a follow-up study of Inhelder and Piaget's The Growth of Logical Thinking, Lovell (1961) used ten of the experiments described in the book and tested 200 Ss ranging in age from 8-18. His results confirmed the main stages in the development of logical thinking set forth by Inhelder and Piaget. Lovell suggested that education could benefit if teachers used the experiments as learning situations and posed problems to children in an effort to get them to suggest possible solutions.

Using a matrix test presented to 80 kindergarten, first, second, and third grade Ss to investigate developmental changes in multiple classification, Parker and Holbrook (1969) identified three bases of classification: Concrete, Functional, and Designative. Performance improved with grade level and there was a significant interaction between grade level and type of classification. Classification with concrete concepts developed before functional classification which developed earlier than designative classification.

Feldman (1966) used an object description task and an unstructured stimulus array consisting of nonsense objects in a free-sort task to ask how children at ages 6 and 8 organize new objects into their experiences. Her procedure consisted of presenting three objects, one at a time, to the child for description, with the child telling her everything he had noticed about the object after it was removed. Then, there were three sortings consisting of the presentation of 18 nonsense objects, then half the objects, and then the other half of the objects. The children were to place in a pile all the objects that belonged together. Then, one of the three original objects was presented and classified in one of the existing piles.

Results on the sorting task indicated that the number of clusters of more than two objects was greater for 8-year-old Ss, as were the number of groups formed. In the object description portion of the study, Feldman found that 8-year-old Ss used more words to describe the objects than the 6-year-old Ss did and were, therefore, able to describe the objects more fully. These findings were interpreted in relation to the function of categorizing at different age levels.

Feldman concluded that very young children use categorization as a means of exploring their environment while for older children it serves as a means of reducing memory load by causing the child to ignore previously noticed aspects of the environment.

Rossi (1964) felt that results concerning the processes involved in classificatory behavior, the time of its developemnt, and whether or not discriminable developmental stages exist for the behavior were contingent upon methods of measurement used. He introduced the "associative clustering" method developed by Bousfield to study the development of classificatory behavior. The Ss, aged 5, 8, and 11, were presented with a randomized list of words from several different conceptual categories, such as animals and clothing, for free recall learning. The amount of categorization was then measured by sequences of conceptually related words which the S spontaneously grouped during free recall. Rossi found a significant deviation from linearity in the relationship between chronological age and clustering in this age range, with a greater gap appearing between ages 5 and 8 than between ages 8 and 11. This was interpreted as providing additional experimental evidence for the developmental stage theory of classificatory behavior set forth by Inhelder and Piaget.

Lee, Kagan, and Rabson (1963) contrasted children with a preference for an analytical conceptual style with children who preferred a relational conceptual style on a standard concept formation task. Their results led them to suggest that Piaget's states of cognitive organization may reflect not only differences in the acquisition of complex rules but also important individual differences in the ways that the relevant stimuli are categorized. Thus, individual differences in the cognitive products of children may be due in part to preferences in the initial processing of information, independent of the differences in the knowledge repertoire of children.

Another result indicative of the effect of variables other than age was found by Clarke and Cooper (1966). In a transfer study of preschool children they found that practice in categorizing seems to improve the process of categorization in a new situation, perhaps by increasing the child's attention to the new task and by giving them experience in making common responses to dissimilar stimuli.

An object-sorting task was administered to Ss from kindergarten to the post-doctoral level by Goldman and Levine (1963) to compare developmental changes in the types of concepts employed. The changes which occurred with increasing age suggested a shift from bases of classification using an immediate, experiential link to the environment to conceptual bases transcending perceptual links.

Annett (1959) compared and analyzed groupings and explanations made by 303 children aged 5-11 and 42 adults aged 18-73 in classifying common objects. The bases of classification she identified were: No Explanation; Enumeration, which was a perceptual linking; Contiguity, which also stressed concrete interactions; Similarities, which consisted of naming attributes; and Class Name. Developmental change occurred in the order of the bases of classification and was related to both IQ and age, with the use of the Enumeration, Contiguity, and Similarities categories first increasing as a function of age, then falling slightly as older children and adults relied on the Class Name category.

She concluded that her findings supported Piagetian theory in the implication that concepts may be attained through stages not apparent upon consideration of their final form in adults.

Finally, two studies on the bases of classification which have direct relevance for the research reported in this paper were performed by Bruner and his co-workers, Olver (1961) and Rigney (1962). Bruner's view that cognitive growth depends on the emergence of the ability to represent regularities in the environment and to transcend the immediate by developing ways of linking past to present to future experience led him to study classification as an example of this growth. The studies on equivalence formation deal with the bases on which individuals categorize things as being alike.

The first study was that of Olver (1961). Olver proposed a theoretical framework for the development of equivalence formation with respect to both attributes and structure of grouping. She theorized that the young child groups objects into various kinds of complexes based on his immediate perceptions. If a child forms categories, he draws on direct experience in making them. The child moves from object to object, selecting as the basis for inclusions into a group whatever perception impresses him at the moment. In contrast, the older child will single out a bond to unify all the items in a group. This is done first at the concrete level and later on the basis of an abstract concept.

Olver then asked how this transition from grouping on the basis of attributes which are immediately perceptible to grouping on the basis of abstracted attributes is accomplished. She suggested that the child makes this transition by referring objects to himself. Specifically, this reference to the self is in terms of the child's self-actions. He comes to group as alike those things which he can somehow act upon in a similar manner. This orientation of "egocentric functionalism" frees the child from overdependence on the sensory situation but tells him little about the intrinsic properties of objects. Eventually, he ceases to position himself outside the system by referring objects to himself and comes to place himself in a reciprocal relationship with them. He is then able to consider what the objects can do as well as what he in turn can do to the objects.

To test her developmental formulation of classifying behavior, Olver administered two verbal arrays to subjects from 6-19 years of age. Items in these arrays were progressively more diverse and the final item represented a contrast class. The arrays were:

1. banana-peach-potato-milk-water-air-germs-stones (with the exception of stones, all are ingestible).
2. bell-horn-telephone-radio-newspaper-book-printing-education-confusion (with the exception of confusion, all teach or communicate something), [Bruner, Olver, and Greenfield, 1966; p. 70]

The Ss were presented with the first two words of an array and asked to explain how the two things were alike. A third card was added and the Ss asked to explain how it was different and how it was like the first two. The procedure was continued until all cards had been presented. This method enable Olver to study the structures of equivalence groupings and the attributes used to tie together the increasingly divergent items.

Five bases of classification were distinguished. Responses were categorized as Perceptible if they were based on immediate, phenomenal qualities; Functional, if they considered the use of the items; Affective, if they were based on an emotional or evaluative reaction; Nominal, if the items were given a class name; and Fiat, if the S merely indicated that the items were alike or different without elaborating further.

Olver's data support the theory that equivalence formation in children develops with age from an early stage of grouping by association on the basis of perceptible attributes to a transitional stage of extrinsic functionalism to a stage of intrinsic or reciprocal functionalism. However, there is continuity across the years in the bases by which individuals categorize.

A second study dealing with bases of classification was that of Rigney (1962). Rigney attempted to assess the generality of Olver's results to a situation where the child himself selected the instances of his groups from a large array, rather than being presented with a sequential series of more divergent items. In addition, pictorial rather than verbal stimuli were used. Rigney hypothesized that if Olver's findings described the general development of classification, these same trends would be evident when tested in a different manner.

Ninety boys, aged 6-11 served as Ss. A rectangular array of 42 pictures was presented to each child and he was asked to find a group of pictures that were alike in some way. After the child explained how the things he grouped were alike, the pictures were replaced in the array and he was asked to make another group. This procedure was continued until ten groups of pictures had been formed.

Rigney pointed out that differences between the pictorial and verbal tasks can be expected to influence the equivalence groups formed. In their discussion of the Rigney study, Bruner et al., (1966) quote the findings of Davidon (1952) on how the nature of the material affects the types of concept formed:

> When grouping verbal symbols, there appears to be a greater tendency to attain concepts based on common use than when grouping pictorial symbols (drawings and photographs). And with pictorial symbols, conversely, there is a greater tendency to attain concepts based upon common parts. [Bruner, et al., 1966, p. 80]

Thus Rigney expected a greater use of perceptible attributes and a lesser use of functional attributes with pictorial stimuli than with verbal stimuli. This was found to be true. At the same time, though, while all children rely more on perceptible attributes with pictorial materials, the younger children still based more of their groupings on the way things looked than did the older children. And while functional attributes increased from ages 6-11, all children used this basis less in the pictorial than in the verbal task at all ag
Rigney found that the nominal basis of grouping in the pictoria task becomes an alternative to the functional basis found in th verbal task.

The use of the nominal category increased steadily with a 6% at age 6 to 23% at age 8 and to 32% at age 11. In the verb however, the use of nominal groupings remained constant at ab from age 6-12. With pictorial stimuli, then, growth seemed to itself in a tendency to use the nominal basis of classificati

Thus, in the Olver and Rigney studies, the same pattern of growth emerged whether pictures or words were used as stimuli, and whether the child was given items in a fixed-order or chose his own groups. Equivalence for the younger child reflects a basis in imagery. With the development of symbolic representation, the child is freed from dependence on momentary variations in perception. A first step comes when the child, at about age nine, takes himself as a reference point for establishing equivalence among things. In time, he moves to more conventional definitions of how things are alike.

In summary, the studies on classificatory behavior reviewed in this section indicate that the ability to classify increases with chronological age. The research suggests changes in the bases of classification moving from a dependence on perceptible attributes through the selection of attributes which focus on the properties of the objects to the forming of hierarchies based on the combination of attributes.

Implications of this research for the present study are that differences in the bases of classification used by Ss in the three age groups should occur and that these differences should appear as a movement from dependence on the Perceptible basis of classification to a preference for the more abstract Attribute and Nominal bases of classification.

Age or Grade Level in Cognitive Growth

While all the studies on the developmental nature of classification reviewed in the first section of this chapter deal with the variable of age as it pertains to cognitive growth, there are several additonal studies which merit attention.

In 1954, Vinacke wrote an article with the intent of formulating what was known about concept formation in children of school age (6-15). His orientation on how children learn concepts was basically Piagetian, but stressed a more gradual, cumulative developmental process. He concluded that increasing age is the single most important variable in concept formation, with changes occurring more rapidly in the early school years. He felt that intelligence was a significant variable as well. Progress was seen as a continuous, cumulative affair as opposed to occurring in distinct phases. Earlier concept learning provided the preparation for later development.

Among the most important specific changes which take place with increasing age are shifts from simple to complex concepts, concrete to abstract concepts, variable to stable concepts, and inconsistent to consistent and accurate concepts.

Osler and Fivel (1961) required Ss to give the same response to different stimuli which belonged to a common category. Subjects in two intelligence groups, normal and superior, and three age groups, 6-, 10-, and 14-years-old, were selected. The age groups were chosen since they represented the extremes and mid-point of the elementary school population and fell within three stages of development as defined by Piaget.

The stimuli were 150 pairs of pictures exemplifying the concepts of bird, animal, and living thing. By guessing the concept, Ss won marbles which could later be exchanged for a toy. Errors to criterion and number of concepts attained indicated a significant effect due to age and intelligence. Osler and Fivel felt that while the finding that age and intelligence are associated with effective concept learning was entirely reasonable, the mechanisms by which the effectiveness is enhanced needed clarification.

They wanted to determine whether the greater effectiveness of the older and more intelligent Ss was due merely to enhanced speed of learning or whether there was a qualitative difference in the learning process. To answer this question, learning curves of individual Ss were examined for the purpose of determining whether concept attainment was gradual or sudden. By examining the S's performance just prior to the final ten correct trials and classifying them as sudden or gradual learners (a sudden learner was below the median for percent correct), they found that the incidence of sudden learning was a function of intelligence, but not of age. Sudden learners were Ss in the higher intelligence group who apparently were attaining concepts by means of hypothesis testing. They thus inferred an association between intelligence and concept attainment by hypothesis testing. This was interpreted to indicate greater use of mediators by the superior Ss.

Lovell, Healey, and Rowland (1962) used twelve of the experiments outlined in Piaget, Inhelder, and Szeminska's The Child's Conception of Geometry (1960) with primary and educationally sub-normal school children. The Ss were presented with the tasks and protocols were then assessed to determine the child's stage of thinking. They found that the main stages in the growth of geometric concepts set forth by Piaget, Inhelder, and Szeminska were broadly confirmed.

A study by Friedman (1965) found a depression in the developmental curve of the relationship between intelligence and concept learning development in fourth-grade children. With the exception of grade 4, there was a continuous increase with grade level in the percentage of children in grades 1-5 correctly producing the required sequences in a task where Ss were to locate tokens behind a series of doors.

Friedman suggested that as the child begins to process sequences of information, he is laying the foundation for a stage of hypothesis formation which apparently begins to come into fruition at grade 4. The child, however, is trying out a technique in which he has no experience. He no longer proceeds by trial and error as younger children do, but he has not yet learned to modify his hypotheses to include new information and thus fails in applying his newly developing ability.

A similar explanation was offered by Tagatz (1967) in an investigation of the influence of grade level (5 and 6), sex, and instructed method of solution on the efficiency of concept learning. The two methods used were commonality and conservative strategy, where concept exemplars were presented in the former and both exemplars and non-exemplars in the latter. He found in analyzing time to criterion and which cards were used that Ss used the commonality strategy more effectively than the conservative strategy, 5th grade Ss were more efficient than 6th grade Ss, and females were more efficient than males.

The significant difference between strategies indicated that most 5th and 6th grade Ss cannot use a conservative strategy requiring more formal logic, a result consistent with Inhelder and Piaget (1958). The inferior performance of the 6th graders was also supportive of Inhelder and Piaget since it indicates that the 6th grade Ss are more aware of the complexity of the task and the combinatorial aspects of the stimuli than the 5th grade Ss who were more efficient at a concrete level. The significant sex effect reflected organismic differences in conceptual behavior and was attributed to advanced verbal development of females.

In summary, studies of concept learning in children of school age are supportive of the Piagetian stage theory of the growth of intelligence. Two studies indicate that school children, at about ages 9-11, seem to have difficulty in successfully shifting from a concrete to an abstract level of concept learning (Friedman, 1965; Tagatz, 1967).

In the present study, 5th-, 8th-, and 11th-grade children served as Ss. On the basis of the research reviewed in this section, one would expect the greatest differences between grade levels to appear between grades 5 and 8, with the 5th-grade Ss relying more heavily on concrete, perceptible bases of classification than the other two groups.

Achievement Level and Cognitive Growth

Levy and Cuddy (1956) were concerned with the development of techniques for predicting which children of normal intelligence are likely to develop learning difficulties. They questioned whether underachievers of normal intelligence differed from normal achievers in their ability to solve a concept learning problem. Their Ss were

23 pairs of fourth grade children of normal intelligence matched for age, sex, and socioeconomic status. One of each pair was working up to grade level and the other was behind from .5 to 2.5 years in achievement as measured by the Stanford Achievement Battery.

The task was an oddity problem, in which Ss were presented with ten sets of Vygotsky blocks. Each set consisted of three wooden blocks, one of which differed from the other two on three dimensions (size, color, and shape). Five series of ten trials were given the Ss with testing discontinued after eleven consecutive correct trials. After the testing, Ss were asked to verbalize how they had solved the problem. Measures used were number of errors, number of trials to criterion, and verbalization of the oddity principle.

In 18 of the 23 pairs, the normal achievers made less errors. Of 11 Ss who reached criterion within fifty trials, 10 were normal achievers; and, of 16 Ss who correctly verbalized the oddity principle, 14 were normal achievers. Thus, every measure demonstrated a significant difference between groups, indicating that underachievers learn concepts more slowly than normal achievers.

The relationship between children's level of concept development and their school attainment was investigated by Freyberg (1966) in the areas of arithmetic computation, arithmetic problem-solving, and spelling over a two-year period. Subjects were 151 New Zealand school children aged 5-7 who were given a 72-item objective test of concept development which included tests of conservation, numerical correspondence, and concepts of position in time and space. Achievement tests were a 120-item speeded computation test, a 25-item test of arithmetic problem-solving, and a 22-item spelling test. The Primary Mental Abilities test was used as a measure of intelligence.

Freyberg found the correspondence between mental age and concept scores to be greater than that of chronological age and concept scores. The addition of concept scores to mental age scores added significantly to the accuracy of predicting attainment as measured by the achievement tests two years later. Results provided confirmation that concept development is more closely linked to the growth of general intelligence than it is to chronological age. But it appeared that children's school performance was associated with aspects of conceptual thinking which are not adequately assessed by intelligence testing.

In her discussion of achievement level differences, Tyler (1965a) summarized by saying that at all grade levels there is an enormous amount of variation in what individual students know. She goes on to say that while intelligence probably accounts for a large portion of the difference (20-50%), what the remaining 50-80% of the variation means is still unclear.

In summary, the level of children's school performance appears to be dependent on aspects of conceptual thinking other than those aspects measured by intelligence tests. The performance of children in high and low achievement groups in the present study of classifictory behavior might provide some information abut these differences in conceptual thinking. The finding that normal achievers progressed more rapidly than underachievers (Levy and Cuddy, 1956) implies that Ss in the high achievement group in the present study might move from the use of concrete to abstract bases of classification at an earlier point in their development than Ss in the low achievement group.

Sex and Cognitive Growth

In an effort to investigate the need for separate sex norms in intelligence testing, Hobson (1947) administered Thurstone's test of Primary Mental Abilities to more than a thousand different eighth and ninth grade boys and girls over a period of five years. His results indicated that girls exceeded boys in mean IQ in each group. In every case, girls exceeded boys on Word Fluency, Inductive Reasoning, and Rote Memory factors while boys exceeded girls by a large margin on the Spatial Relations factor.

Terman and Tyler (1954) found that girls excel on verbal problems while boys perform better than girls in mathematical reasoning and spatial problems. In all cases ability differences were most apparent as age increased.

In 1962, Archer performed a study to manipulate the variable of obviousness of information as a characteristic affecting concept identification. He predicted that if relevant information was obvious, the concept would be easy to attain and if irrelevant information was obvious, the concept would be hard to attain. The relevant dimensions were form and size. Subjects were 128 college students, 64 male and 64 female, who were told that they would see different patterns and were to assign each pattern to one of four categories by pressing a switch. A lamp would light over the switch which was correct.

When the responses were analyzed with time to criterion as the variable, Archer found that the predicted interaction between relevance and obviousness was significant. However, an unexpected significant interaction between sex, manipulated dimension, and relevance occurred. The two sexes did not behave differently when size was relevant or irrelevant, but when form was relevant men found the task fairly easy and when form was irrelevant men found the task very difficult. When form was relevant, women found the task difficult and when form was irrelevant, women found the task easier.

To seek an explanation for this result, Archer showed the same stimuli used in the most complex form variation condition to 40 male and 40 female Ss and asked them to describe what they saw. Aside from number, color, and white dot, men usually described the stimuli as squares or non-squares or even tippy squares. Archer hypothesized that the obviousness of a level within a dimension can be modified by the S's labeling ability. Thus, men who could label forms found when form was relevant that the task was easier. This implied to Archer that inner speech modified problem-solving behavior and that verbal pretraining will affect performance on problem-solving tasks like concept identification.

In a study by Pishkin, Wolfgang, and Rasmussen (1967) which explored the effects of three levels of availability of correctly and incorrectly sorted instances in a four-choice learning task, the authors found an interaction between sex and type of instance available. The superiority of the females' performance in using more instances was explained by saying that females gain more from memory and are better able to utilize information beyond the availability of one instance. This is consistent with Tyler's (1965a) finding that females are better at memory tasks such as recalling digits and reproducing patterns from memory.

Kagan and Lemkin (1961) ran a study of children's tendency to use form, color, and size in classifying stimuli into groups. They presented 34 boys and 35 girls aged 3-8 with stimulus cards differing in color, size, and form and asked them to tell which of the stimuli at the top of the card most closely resembled the bottom one. Among their findings was the fact that older boys preferred color more often than form. The authors hypothesized that girls used form more because their language ability was better developed and they applied labels to the stimuli more often than boys. Thus, for the girls the stimuli are more likely to derive their meaning from the label rather than through the more direct physical quality of color.

This is not consistent with the results of Archer (1962). Apparently, younger girls are able to use labels more efficiently due to their more highly developed language ability, but as age increases the more highly developed ability of boys in the area of mathematical reasoning overcomes the language advantage. Thus, in college age Ss, the boys excel when form is relevant because they are better able to apply labels to the mathematical concepts which are presented.

In summarizing her findings on sex differences, Tyler (1965b) mentioned a study by Sweeney (1953) where males were found to be superior on all problems requiring what he called restructuring, situations in which the person must discard his first system of organizing facts and try a new approach.

In summary, sex differences measured in a variety of tasks have indicated that girls excel in memory, verbal fluency, perceptual speed, and manual dexterity, while boys excel in spatial relations, mathematical relationships, and science. It is possible that the younger girls might have an advantage due to their superior verbal ability when functioning at a concrete level, but that with increasing age, the need to rely on abstract mathematical relationships in classifying the concepts would put the boys at an advantage on the classification task.

Pictorial vs. Verbal Method of Presentation

One of the most inclusive studies in the area of pictorial and verbal methods of presentation was designed by Davidon (1952). He wanted to measure how effectively persons can use various symbols to organize the objects of their experience. His hypothesis was that adults would attain fewer concepts when symbols were at a high level of abstraction. Four levels of abstraction were defined. In order of abstraction from the most abstract to the least abstract, the levels were: short names, long names, drawings, and photographs.

The task required the 108 college students to find and label as many mutually-exclusive three card groups as they could within the allocated time period. Half the Ss saw cards with names and half with pictures. In the name group, half were long and half were short names. Similarly, half the pictorial group saw drawings and the other half photographs. The measure used was the number of concepts attained.

Davidon found that the type of symbol used to represent a n[illegible] of familiar objects did influence the efficiency with which college students could organize these objects into separate classes. Performance with long names was inferior to short names and also less tha that with photographs or drawings, which did not differ from each other. Davidon suggested that differences in the perception of words and pictures affected the efficiency of organization.

Since Davidon suspected that Ss who were presented with different types of symbols tended to form different types of concepts, he then categorized the Ss' responses as concepts based on Use, Shape, Parts, Action, and Others and found there was a relationship between the type of symbol presented and the type of concept attained. When verbal symbols were grouped, the concepts attained were based on use, while pictorial symbols tended to produce concepts based on common parts.

Another study involving pictorial and verbal presentation was that of Davidon and Longo (1960). They obtained free associations to names and pictures of common objects from 20 Ss in each of three age groups: fourth grade (10 years), eighth and ninth grades (13-15 years), and freshmen and sophomore college students (18-21 years). They found that association to pictures was more rapid than to words, especially for the ten-year-old group.

Runquist and Hutt (1961) compared the learning of verbal concepts from pictorial representations with the learning from the more standard verbal representations. They used three conditions: Verbal where the name of the object was used; Picture Dominant, where the correct association was emphasized by the picture; and Picture

Non-Dominant, where the correct association was deemphasized by the picture. Sixty high school Ss, 15 at each grade level, were compared on a verbal learning task where sixteen high-dominant concepts from the Underwood and Richardson materials were used.

An analysis of variance of mean number of correct responses for each group over fifteen trials showed that the method of presentation and grade level were significant. The Verbal group performed better than the Picture Dominant group who performed better than the Picture Non-Dominant group.

Two interpretations were offered for the better performance when words were used as stimuli. First, it was suggested that the subject was using the same medium as the stimulus in making the response and thus may not have used an image at all but merely responded with a highly likely verbal association. Second, the quality of the concepts used in the study (i.e., soft, sharp) was more tactile than visual. Runquist and Hutt concluded that no simple answer to the question of which type of presentation was superior had been obtained.

Although the methods of presentation used by Anderson and Johnson (1966) differed slightly from pictorial vs. verbal presentation, the results can still be considered comparable to the other studies. They utilized a perceptual condition where information critical to the solution of the problem was presented by means of a simple demonstration and contrasted it with a verbal condition where the same information was presented in a short verbal statement and a control condition in which the information was not presented at all. Sixty female Ss took part in the experiment. The task was a rotating weights problem.

There was a significant linear trend between the information condition and the solution score such that solution scores for the perceptual condition were higher than those for the verbal condition which were higher than those for the control condition. In addition, most Ss reported using images, but imaging was significantly correlated with solution score (r = .55) only in the perceptual condition.

Anderson and Johnson interpreted their results in accordance with Bruner's (1964) and Piaget's (Flavell, 1963) evidence showing that early thinking is heavily dependent on concrete, perceptual experience. The authors suggested that the differences between the perceptual and verbal conditions lay in the perceptual immediacy with which information was presented. They concluded that perceptual immediacy was one variable which was related to the usefulness of previous experience in problem-solving.

Finally, a series of studies was conducted by Wohlwill (1968) comparing children's responses to Piagetian class-inclusion questions (i.e., Given 6 dogs and 2 horses, are there more dogs or animals?). He used both pictorial and purely verbal forms of presentation. Over several replications with Ss of 5-7 years of age, there was a consistent superiority of the verbal condition over the pictorial.

This superiority was attributed to the weakening of a subclass comparison set engendered by the perception of majority and minority subclasses in the pictorial group. Wohlwill suggested that at this age level, there might exist an intermediate stage in which the child is starting to be able to bear in mind the subclass and the total class simultaneously. The process is apparently facilitated in the absence of the stimuli defining the subclasses.

In summary, the type of symbol used to represent an object influences the efficiency of concept learning and the type of concept attained, with pictorial stimuli eliciting perceptual responses and verbal stimuli eliciting functional responses. Reliance on perceptual cues appears to be helpful for younger Ss and for Ss who have had no previous experience with the concepts presented. In addition, verbal stimuli appear to elicit verbal responses.

These studies imply that Ss presented with pictorial stimuli in the present study will use the Perceptible basis of classification more than the Ss who are presented with the verbal stimuli. It is also possible that Ss who are presented with the verbal stimuli will use the Nominal basis of classification more than Ss who are presented with pictorial stimuli.

Chapter 3

EXPERIMENTAL METHOD

The purpose of this experiment was to ascertain the relationship of grade level, achievement level, sex, and method of presentation to the various bases by which students classify geometric concepts. The specific questions which the experiment sought to answer were:

1. Do children in grades 5, 8, and 11 differ in their bases of classifying geometric figures?
2. Do children of high and low mathematical achievement level differ in their bases of classifying geometric figures?
3. Do boys and girls differ in their bases of classifying geometric figures?
4. Do verbal and pictorial presentations results in differing bases of classifying geometric figures?
5. Does the percentage of correct classifications differ between grade levels, achievement levels, sexes, and methods of presentation?

Subjects

The subjects in this study were 96 students enrolled in the fifth, eighth, and eleventh grades, 32 at each grade level. The fifth-grade Ss were students at Atwater Elementary School, Shorewood, Wisconsin.

The eighth-grade Ss were students at Shorewood Intermediate School and the eleventh-grade Ss were students at Shorewood High School.

Subjects were stratified by mathematical achievement level and sex within each grade level. To determine mathematical achievement level of each student, standardized achievement test scores were secured from the school records. The Arithmetic Skills subtest score of the Iowa Test of Basic Skills (Lindquist & Hieronymus, 1964) was used for the fifth-grade students. An average of the Arithmetic Concepts and Arithmetic Applications test scores of the Stanford Achievement Battery (Kelley, Madden, Gardner, & Rudman, 1964) was used for eighth-grade students, and the Mathematic Usage subtest score of the National Educational Development Test (Science Research Associates, 1968) for eleventh-grade students.

Norms were reported in terms of percentile ranks on each of the test batteries. Since in each case the local norms were considerably above the national norms, the students were dichotomized on mathematical achievement level according to the local norms. Those Ss at each grade level who performed above the median for their school were assigned to the high achievement group and students performing below the local median were assigned to the low achievement group.

After the students at each grade level were stratified according to mathematical achievement level and sex, eight Ss were randomly selected for each achievement level x sex cell, for a total of 32 Ss at each grade level. Within each cell, Ss were randomly assigned to either the verbal or pictorial presentation groups for Task 1. Each student who participated in the experiment was used for the final analysis. There were four S in each possible combination of achievement level, sex, and method of presentation for each of the three grade levels.

Experimental Materials

Materials utilized were designed to meet the specifications of the experiment. Geometric concepts were selected because of their explicit definition and because they were concepts which are taught in the classroom. It will be recalled that the Bruner studies used lists of concepts which were constructed impressionistically from a universe of things (Bruner, et al., 1966, p. 70). A set of concepts more closely allied to school learning might contribute information on how children categorize concepts which are taught to them in school.

The first task consisted of the sequential presentation of eight geometric concept instances. The concepts used and their attributes are listed in Table 1. The geometric concepts selected for this research and the list of their attributes shown in Table 1 were adapted from those employed in a study by Frayer (1970).

As in the Olver (1961) study, the instances used in Task I were progressively more diverse and the final instance was a contrast item. The array consisted of: square-rectangle-rhombus-parallelogram-quadrilateral-triangle-circle-cube. Half the Ss at each grade level were shown cards with pictures of concept instances printed on them. The size of the cards, which measured 4" x 6", was selected both for

TABLE 1

Concepts Used in Task I and Their Relevant Attributes

Concept Name	Attributes	
Square	Simple Closed Plane 4-Sided	All sides equal length 4 90-degree angles Opposite sides parallel
Rectangle	Simple Closed Plane	4-Sided 4 90-degree angles Opposite sides parallel
Rhombus	Simple Closed Plane	4-Sided All sides equal length Opposite sides parallel
Parallelogram	Simple Closed Plane	4-Sided Opposite sides parallel
Quadrilateral	Simple Closed	Plane 4-Sided
Triangle	Simple Closed	Plane 3-Sided
Circle	Simple Closed	Plane All points equidistant from the center
Cube (contrast item)	Simple Closed	Solid 6 faces, each with 4 sides

ease of viewing by the Ss and ease of manipulating by the experimenter. All of the cards were white and had either a picture or a name printed on it in black ink.

The second task, a free-sort, simultaneous presentation task similar to that used by Rigney (1962), used a 26-picture array of geometric concept instances. The concepts were the same as those used in the first task, except that instances of the contrast class item, "cube," were not included. Instances of the seven geometric concepts were varied along the irrelevant attributes of size and orientation to yield the array described in Table 2. It will be noted that the concept "circle" was varied only in size, resulting in a 26-card array. Again, the concept instances were printed in black ink on white cards that measure 4" x 6". The materials used in Task I and Task II are illustrated in Appendix A.

Procedure

The two tasks were administered consecutively to each subject in one session, which varied in length from 15-30 minutes, with the fifth grade Ss usually requiring the most time to complete the experiment. The sessions were conducted in an unoccupied room at each of the schools. A tape recording was made of the responses of each subject on Task I; a verbatim written record was kept of the cards sorted and the explanations offered by each S on Task II. The S was given instructions concerning the procedures to be followed prior to each task. A copy of these instructions comprises Appendix B.

The first task consisted of the presentation of eight cards bearing either concept names or concept instances. The cards were

TABLE 2

Description and Order of Concept Instances for Task II

Small[1] square	Large[6] circle	Small[11] rhombus	Large[16] rectangle	Left[21] oriented quadri- lateral	Upside[26] down triangle
Small[2] parallelo- gram	Small[7] quadri- lateral	Large[12] triangle	Right[17] oriented parallelo- gram	Upright[22] square	
Right[3] oriented quadri- lateral	Vertical[8] rectangle	Small[13] circle	Small[18] rectangle	Left[23] oriented rectangle	
Right[4] oriented rhombus	Tilted[9] square	Large[14] parallelo- gram	Large[19] square	Left[24] oriented parallelo- gram	
Small[5] triangle	Left[10] oriented rhombus	Large[15] quadri- lateral	Large[20] rhombus	Left[25] oriented triangle	

placed on a table in front of the S, one at a time. He was presented with the first two cards and asked to explain how they were alike. The third card was then presented and the S asked how it differed from the first two and then how all three were alike. This procedure was continued until all the cards except "cube" were included in a similarity formation. The S was then asked to tell how "cube" differed from the other seven cards. There were six questions concerning likenesses and six questions concerning differences between stimuli. For Ss in the verbal condition, words were routinely pronounced as the cards were presented. The concept name was not given to Ss in the pictorial condition. The Ss had the opportunity to ask questions as they proceeded through the task. Requests for clarification of the procedure were answered.

Following Task I, the experimenter administered Task II which was the free-sort of geometric concept instances. The 26-picture array was set up on a table before the S in the order described in Table 2. After the instructions had been given, the S was directed to look at the cards to insure that he had seen the entire array.

The S was then asked to form a group of pictures that were alike in some way. After the S explained how the things he grouped together were alike, the pictures were replaced in the array and he was asked to form another group. This procedure was continued until seven groups of pictures had been formed. The S was not informed of the number of groups he was to sort. If a subject spontaneously stopped prior to the completion of the task, he was asked to continue until all seven groups had been formed. Again, if questions arose relating to procedure, they were answered.

Scoring of the Data

To determine the appropriateness of the tasks and instructions and to help establish scoring criteria for the responses, a pilot study was carried out. The tasks as described above were administered to eight Ss at each grade level. The Ss were stratified according to achievement level and sex and randomly assigned to verbal or pictorial presentation groups. After the experimenter was satisfied with the appropriateness of the tasks and the clarity of the instructions, the responses given by the 24 Ss were utilized to develop the scoring system for the subsequent experimentation. A description of the bases of classification used to categorize the responses made by the Ss on each task and the criteria by which a response was assigned to a category follow.

The five bases of classification distinguished by Olver (1961) provided direction for the classification system which was devised. However, the differences in the materials demanded some modification in these bases of classification. The four bases of classification which were used in this study are given in Table 3. The Perceptible, Nominal, and Fiat categories remain unchanged, but the Affective and Functional categories used by Olver have been excluded. The Affective category was not used since it was considered highly unlikely that a geometric concept would arouse an emotion or have a value attached to it. Also, the Functional category did not seem relevant in that a square or rectangle does not have a function in the sense that a banana or bell does. An Attribute category was added. Responses naming a specific attribute of a concept were placed in this category.

TABLE 3

A System for Categorizing Task I and Task II Responses

1. Perceptible: The child may render the items equivalent on the basis of immediate phenomenal qualities, such as color, size, shape, or on the basis of position in time or space.

   Example: They are alike because they are both black figures on white cards.
   They are both printed in black ink.
   The lines are straight, not slanted.
   They are tilted to the right.
   This one is round.
   One is longer than the other.
   They are diamond-shaped.

2. Attribute: The child renders the items equivalent or diverse by naming a specific attribute of the concept.

   Example: They all have four sides.
   They are closed figures.
   They are plane figures.
   They are made of line segments.

3. Nominal: The child may group items by giving a name that exists ready-made in the language. A supraordinate concept name is used as the basis of grouping.

   Example: They are all parallelograms.
   They are diamonds.
   Both the square and the rectangle are rectangles.
   They are all geometric figures.

4. Subject-Fiat: The child may merely state that the items are alike or are the same without giving any further information as to the basis of his grouping, even when he is prodded.

   Example: They are alike.
   They are just different.

After the scoring system had been devised, the twenty-four protocols from the pilot study were scored by the experimenter. The same protocols were scored by an independent rater to determine the reliability of scoring. When the results of the independent judgments were compared, it was found that the Attribute and Perceptible classifications needed more stringent definition. Changes were instituted, resulting in the system of categorization shown in Table 3.

Another change in the scoring system made prior to the final experiment involved Task II. Since Ss were allowed to select their own groups and then asked why they had made that selection, they were always able to give a reason that could be categorized. Therefore, the Subject-Fiat classification was eliminated for the second task. This resulted in a scoring system utilizing Perceptible, Attribute, Nominal, and Subject-Fiat categories for Task I and Perceptible, Attribute, and Nominal categories for Task II responses. For Task I, the number of responses in each classification category were tabulated separately for the likeness and difference judgments the Ss were asked to make. The likeness and difference questions were considered as subtasks of Task I.

In scoring the pilot study protocols, it was found that although the responses made by the Ss could now be easily categorized, many of them were not correct responses. Thus, a S might respond that a quadrilateral was different from the preceding concepts because it had three sides, a response that was classified as "Attribute" but which was none the less incorrect. It was reasonable to suspect that changes in the number of correct responses might occur along the dimensions of grade level, achievement level, sex, or method of presentation. An additional measure was utilized to detect such changes. The proportion of the number of correct responses to the total number of responses was tabulated for each S on each task.

In summary, thirteen original dependent variables were tabulated for each S: the number of responses to likeness and difference questions for each category on Task I, the number of responses in each category on Task II, and the proportion of correct responses to total responses for Task I and Task II.

Design and Statistical Analysis of the Data

The independent varibale in this experiment is method of presentation. The stratifying variables are grade level, achievement level, and sex. The 2x3x2x2 design is illustrated in Table 4.

The original dependent variables employed were the number of initial responses in each classification category for likeness and difference subtasks of Task I, summed over concepts; the number of initial responses in each category on Task II, summed over sorts; and the percentage of correct responses on Task I and Task II.

To answer the questions dealing with the effects of grade level, achievement level, sex, and method of presentation, multivariate analyses of variance were carried out with two 2x3x2x2x multivariate analyses of variance. For Task I, the dependent variables for the analyses were two linear contrasts among three of the original variables. The following linear contrasts on the dependent variables for the first analysis were generated:

TABLE 4

Design of the Experiment

	Grade 5				Grade 8				Grade 11			
	Male		Female		Male		Female		Male		Female	
	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Verbal	S_1	S_9	S_{17}	S_{25}	S_{33}	S_{41}	S_{49}	S_{57}	S_{65}	S_{73}	S_{81}	S_{89}
	S_2	S_{10}	S_{18}	S_{26}	S_{34}	S_{42}	S_{50}	S_{58}	S_{66}	S_{74}	S_{82}	S_{90}
	S_3	S_{11}	S_{19}	S_{27}	S_{35}	S_{43}	S_{51}	S_{59}	S_{67}	S_{75}	S_{83}	S_{91}
	S_4	S_{12}	S_{20}	S_{28}	S_{36}	S_{44}	S_{52}	S_{60}	S_{68}	S_{76}	S_{84}	S_{92}
Pictorial	S_5	S_{13}	S_{21}	S_{29}	S_{37}	S_{45}	S_{53}	S_{61}	S_{69}	S_{77}	S_{85}	S_{93}
	S_6	S_{14}	S_{22}	S_{30}	S_{38}	S_{46}	S_{54}	S_{62}	S_{70}	S_{78}	S_{86}	S_{94}
	S_7	S_{15}	S_{23}	S_{31}	S_{39}	S_{47}	S_{55}	S_{63}	S_{71}	S_{79}	S_{87}	S_{95}
	S_8	S_{16}	S_{24}	S_{32}	S_{40}	S_{48}	S_{56}	S_{64}	S_{72}	S_{80}	S_{86}	S_{96}

A. The number of perceptible responses minus the average number of attribute and nominal responses ($P - \overline{A + N}$).

B. The number of attribute responses minus the number of nominal responses (A - N).

The contrasts which served as the dependent variables for the second multivariate analysis compared scores on interactions between the likeness and difference subtasks and were as follows:

A. The number of perceptible difference, attribute and nominal likeness responses minus the number of perceptible likeness, attribute and nominal different responses (Interaction 1).

B. The number of attribute difference, nominal likeness responses minus the number of attribute likeness, nominal difference responses (Interaction 2).

A univariate analysis of variance with the orthogonal contrast of Likenesses minus Differences for the Subject-Fiat category was also carried out for Task I. The dependent variable for this analysis was the number of Subject-Fiat responses given by <u>S</u>s when they were asked to describe similarities between stimuli minus the number of Subject-Fiat responses given by <u>S</u>s when they were asked to describe differences between stimuli (S Like - S Diff).

A multivariate analysis of variance with method of presentation, grade level, achievement level, and sex as factors was carried out for Task II. The dependent variables for the analysis were linear contrasts among three of the original variables. The following linear contrasts on the dependent variables were generated:

A. The number of perceptible responses minus the average number of attribute and nominal responses (P - A + N).

B. The number of attribute responses minus the number of nominal responses (A - N).

To answer the question dealing with the correctness of responses separate univariate analyses of variance were carried out on the percentage of correct responses for Task I and Task II. Comparisons were made between grade levels, achievement levels, sexes, and methods of presentation.

Chapter IV

RESULTS AND DISCUSSION

This chapter contains the results and discussion. The two tasks were analyzed separately and are, therefore, reported separately. First, the results and discussion of Task I are presented, including both the analyses of bases of classification used and the percentage of correct responses made. The same procedure is followed in discussing the results of Task II. Finally, comparisons are made between the fixed-order and free-sort tasks.

Results and Discussion - Task I

For each S on Task I, the number of initial responses in each classification category was tabulated. The categorization of initial responses is shown in Appendix C. It will be recalled that Ss in Task I were asked to tell both how the geometric concepts were alike and how they were different from each other. In order to determine whether any differences existed in the bases of classification used on these subtasks, initial responses were considered for the six questions concerning likenesses and the six questions concerning differences between the stimuli. There were, therefore, twelve responses for each S. Each response was then categorized as Perceptible (P), Attribute (A), Nominal (N), or Subject-Fiat (S). If a perceptible response was given when a S was questioned about differences between stimuli, it was tabulated as a Perceptible Difference (P Diff) response; if it was given when a S was questioned about likenesses between stimuli, it was tabulated as a Perceptible Likeness (P Like) response. The abbreviations "Diff" and "Like" thus occur after each P, A, N, and S categorization for Task I and are hereafter used in the tables and in the discussion.

An inter-rater reliability check was performed after the protocols had been scored by the experimenter. A random sample of twenty-four protocols from Task I and twenty-four different protocols from Task II were independently categorized according to the scoring system previously described (See Table 3). The percentage of agreement between the two independent ratings was 89.2% for the initial response data on Task I and 98.8% for the initial response data on Task II.

The mean number of initial responses in each classification category as a function of grade level, achievement level, and sex for the verbal and pictorial presentation groups are shown in Table 5.

Originally, the total number of responses in each category had been tabulated and expressed as proportions of the total number of responses for each S so that all the data could be used for the final analysis. However, two problems in the statistical analysis of the data eliminated the use of the total response analyses. One option had been to analyze the bases of classification univariately, but the correlation between the bases of classification would not allow

TABLE 5

Means and Standard Deviations of the Number of Initial Responses In Each Classification Category as a Function of Grade, Achievement Level, and Sex for the Verbal and Pictorial Presentation Groups

Achievement Level	Sex	Treatment	P Like	A Like	N Like	S Like	P Diff	A Diff	N Diff	S Diff
			Grade 5							
High	Male	Pictorial	1.5 (2.38)	2.75 (2.22)	1.5 (1.91)	.25 (.50)	2.75 1.26)	2.0 (1.63)	.25 (.5)	1.0 (.82)
		Verbal	1.5 (2.38)	3.0 (2.16)	1.25 (1.5)	.25 (.50)	2.25 (.96)	2.5 (1.0)	0 (0)	1.25 (.5)
	Female	Pictorial	.75 (.96)	4.5 (1.29)	.25 (.5)	.50 (1.0)	2.5 (1.0)	3.0 (1.15)	0 (0)	.5 (1.0)
		Verbal	.25 (.5)	2.75 (1.26)	2.0 (1.63)	1.0 (1.41)	1.0 (0)	3.0 (.82)	0 (0)	2.0 (.82)
Low	Male	Pictorial	1.75 (1.71)	3.25 (1.22)	.25 (.5)	.75 (.96)	3.25) (.5)	1.5 (1.29)	0 (0)	1.25 (1.26)
		Verbal	.5 (.58)	3.75 (1.26)	1.75 (.96)	0 (0)	1.25 (1.26)	3.5 (1.13)	0 (0)	1.25 (.5)
	Female	Pictorial	1.75 (2.36)	2.75 (1.89)	1.0 (.82)	.5 (.58)	2.75 (1.26)	3.0 (.82)	0 (0)	.25 (.5)
		Verbal	0 (0)	3.25 (2.06	0 (0)	2.75 (2.06)1	1.5 (1.29)	2.25 (.50)	0 (0)	2.25 (1.26)
GRADE MEAN			1.0	3.25	1.0	.87	2.16	2.59	.03	1.09

Note. - Standard deviations are given in parentheses.

TABLE 5 (continued)

Achievement Level	Sex	Treatment	P Like	A Like	N Like	S Like	P Diff	A Diff	N Diff	S Diff
			Grade 8							
High	Male	Pictorial	3.75 (2.06)	1.25 (.96)	0 ( )	1.0 (1.41)	2.0 (1.41)	3.0 (1.41)	0 (0)	1.0 (0)
		Verbal	.25 (.5)	4.75 (1.5)	.75 (1.5)	.25 (.5)	.25 (.5)	4.75 (1.26)	.25 (.5)	.75 (.96)
	Female	Pictorial	0 (0)	5.5 (.58)	.25 (.5)	.25 (.5)	.75 (.96)	5.25 (.96)	0 (0)	0 (0)
		Verbal	.25 (.5)	5.25 (.96)	.5 (1.0)	0 (0)	0 (0)	4.25 (1.26)	0 (0)	1.75 (1.26)
Low	Male	Pictorial	1.5 (2.38)	3.0 (2.16)	1.0 (1.15)	.5 (.58)	2.25 (.5)	2.75 (1.26)	.25 (.5)	.75 (1.5)
		Verbal	.5 (.58)	2.25 (1.71)	2.25 (2.06)	1.0 (0)	1.0 (1.15)	2.75 (1.5)	0 (0)	2.25 (.5)
	Female	Pictorial	.75 (.96	3.75 (2.22)	..75 (1.50)	.75 (.5)	3.25 (.96)	1.75 (2.06)	0 (0)	1.0 (1.15)
		Verbal	.25 (.50)	2.5 (1.29)	1.5 (2.38)	1.75 (1.26)	1.75 (.96)	2.75 (1.26)	0 (0)	1.5 (.58)
GRADE MEAN			.91	3.53	.84	.62	1.41	3.41	.06	1.03

TABLE 5 (continued)

Achievement Level	Sex	Treatment	P Like	A Like	N Like	S Like	P Diff	A Diff	N Diff	S Diff
			Grade 11							
High	Male	Pictorial	1.0 (1.15)	3.75 (.5)	1.0 (1.15)	.25 (.5)	1.0 (1.41)	4.25 (1.50)	.5 (.58)	.25 (.5)
		Verbal	0 (0)	3.5 (1.73)	2.5 (0)	0 (0)	0 (0)	5.75 (.5)	2.5 (.5)	1.0 (0)
	Female	Pictorial	.25 (.5)	3.75 (1.26)	1.5 (1.91)	.5 (1.0)	.75 (1.5)	5.0 (1.41)	.25 (.5))	0 (0)
		Verbal	.25 (.5)	2.25 (1.5)	3.25 (1.5)	.25 (.5)	.75 (.96)	4.5 (1.29)	.25 (.5)	.5 (.58)
Low	Male	Pictorial	.75 (1.5)	2.25 (1.71)	2.0 (1.82)	1.0 (1.41)	1.25 (1.5)	3.0 (1.82)	.25 (.5)	1.5 (1.91)
		Verbal	0 (0)	5.25 (1.5)	0 (0)	.75 (1.5)	1.25 (.96)	2.75 (.96)	0 (0)	2.0 (.82)
	Female	Pictorial	.75 (1.5)	3.5 (2.52)	1.5 (1.29)	.25 (.5)	2.5 (1.0)	2.75 (.50)	.25 (.50)	.5 (1.0)
		Verbal	0 (0)	4.25 (1.26)	.25 (.50)	1.5 (1.0)	.75 (.96)	3.5 (1.29)	0 (0)	1.75 (.5)
	GRADE MEAN		.37	3.56	1.62	.56	1.03	3.94	.22	.81

this. The other alternative had been to eliminate a category, i.e., Subject-Fiat, so that a multivariate analysis of variance could be carried out on the proportion of total responses in the Perceptible, Attribute, and Nominal categories. When dependent variables which are linear combinations of one another and are expressed as a series of percentages sum to 1.00, at least one of the variables involved must be removed from the analysis. However, the number of subject-fiat responses used to describe both likenesses and differences between stimuli was too small, and the proportions still totaled 1.00 in several cells.

Thus, it was decided to use the number of initial responses in the final analysis of the data for Task I and Task II. The mean proportions of total responses in each classification category on each task are shown in Appendix D.

Although it was with reluctance that the total response data was eliminated, it was not considered to be a decision made to the detriment of the study. In fact, the initial response given by a S is probably his most powerful statement and these responses should reflect any trends in changes in the bases of classification used by Ss in different groups.

The Perceptible, Attribute, and Nominal categories of classification used to describe likenesses and differences between stimuli were linearly combined into two orthogonal contrasts which then became the dependent variables in the first multivariate analysis of variance for Task I. One dependent variable was the contrast formed by taking the average of the number of initial responses in the Attribute and Nominal categories and subtracting it from the number of initial responses in the Perceptible category ($P-\overline{A+N}$). This contrast was designed to determine the difference in the use of the lower-order Perceptible category vs. higher-order Attribute and Nominal categories.

The other dependent variable was the difference between the higher-order Attribute and Nominal categories (A-N). The use of these contrasts among the bases of classification responses as dependent variables in the analysis allowed the testing of interactions of the bases of classification with the independent variables of grade level, achievement level, sex, and method of presentation.

The second multivariate analysis of variance also used two linear contrasts as the dependent variables in order to determine the interactions of the bases of classification with the independent variables when likeness and difference scores were considered. The first dependent variable was the contrast between the number of initial responses in the categories: Perceptible Difference, Attribute and Nominal Likeness minus the number of initial responses in the Perceptible Likeness, Attribute and Nominal Difference categories (P Diff, A, N Like - P Like, A, N Diff, hereafter called Inter 1). The second dependent variable was the difference between the Attribute Difference, Nominal Likeness categories and the Attribute Likeness, Nominal Difference categories (A Diff, N Like - A Like, N Diff, hereafter called Inter 2). The use of these contrasts among the bases of classification as dependent variables allowed the testing of interactions of the bases of classification with the independent variables when likeness and difference responses were considered.

Finally, a univariate analysis of variance was carried out with the linear contrast between subject-first responses in the likeness and difference subtasks as the dependent variable (S Like-S Diff). This analysis allowed the testing of differences between the subtasks with the independent variables of grade, achievement level, sex, and method of presentation.

The multivariate and univariate analyses of variance were carried out using Finn's (1968) computer program. The results of the analyses of the bases of classification are found in Tables 6 and 7. The significance level selected for the tests was .05. To interpret the univariate F tests for the two multivariate analyses, the alpha level was set at .025. This was in accordance with a strategy suggested by Miller (1966) for controlling the error rate for tests considered jointly. The significance level for the individual F tests is set at α/k where k is the number of tests being interpreted. For each multivariate F test, a univariate F test of each of the combination scores was carried out. Thus, the significance level of .025 for the individual F tests maintains the overall error rate of .05.

Perceptible, Attribute, and Nominal Response Analyses

Tables 6 and 7 report the multivariate and univariate analyses of the bases of classification used by Ss on Task I. Table 6 summarizes

TABLE 6

Multivariate and Univariate Analyses of Variance of Initial Responses on Task I Contrasting the Perceptible, Attribute, and Nominal Categories

Source	Multivariate Analysis F	df	Probability	Contrast	Univariate Analysis F	df	Probability
Grade	4.07	4,142	<.0038*	P-AN	7.69	2,72	<.0010*
				A-N	1.52	2,72	<.2264
Achievement	3.79	2,71	<.0274*	P-AN	6.32	1,72	<.0142*
				A-N	4.30	1,72	<.0417
Sex	1.48	2,71	<.2355	P-AN	2.11	1,72	<.1505
				A-N	2.08	1,72	<.1538
Treatment	8.95	2,71	<.0004*	P-AN	16.70	1,72	<.0002*
				A-N	.28	1,72	<.5996
G x A	3.37	4,142	<.0115*	P-AN	.90	2,72	<.4101
				A-N	6.05	2,72	<.0038*
G x S	.83	4,142	<.5087	P-AN	.91	2,72	<.9092
				A-N	1.43	2,72	<.7621
G x T	.76	4,142	<.5525	P-AN	.57	2,72	<.5659
				A-N	.40	2,72	<.6691
A x S	1.98	2,71	<.1462	P-AN	4.00	1,72	<.0492
				A-N	.55	1,72	<.4628

TABLE 6 (continued)

Source	Multivariate Analysis F	df	Probability	Contrast	Univariate Analysis F	df	Probability
A x T	1.10	2,71	<.3392	P-AN	.05	1,72	<.8248
				A-N	2.08	1,72	<.1538
S x T	2.74	2,71	<.0715	P-AN	2.64	1,72	<.1087
				A-N	4.91	1,72	<.0300
G x A x S	.98	4,142	<.4208	P-AN	1.30	2,72	<.2786
				A-N	1.41	2,72	<.2520
G x A x T	2.65	4,142	<.0356*	P-AN	1.08	2,72	<.3465
				A-N	4.43	2,72	<.0154*
G x S x T	.53	4,142	<.7105	P-AN	.87	2,72	<.9231
				A-N	.01	2,72	<.9890
A x S x T	1.73	2,71	<.1847	P-AN	1.47	1,72	<.2287
				A-N	3.22	1,72	<.0772
G x A x S x T	1.49	4,142	<.2098	P-AN	2.35	2,72	<.1029
				A-N	.34	2,72	<.7148

*Significant at the indicated level.

TABLE 7

Multivariate and Univariate Analyses of Variance of Initial Responses on Task I Contrasting the Use of Perceptible, Attribute, and Nominal Categories on Likeness and Difference Subtasks

Source	Multivariate Analysis F	Multivariate Analysis df	Probability	Contrast	Univariate Analysis F	Univariate Analysis df	Probability
Grade	1.89	4,142	<.1160	Inter 1**	2.33	2,72	<.1042
				Inter 2**	1.95	2,72	<.1491
Achievement	5.02	2,71	<.0092*	Inter 1	9.49	1,72	<.0030*
				Inter 2	3.72	1,72	<.0578
Sex	1.54	2,71	<.2210	Inter 1	3.09	1,72	<.0832
				Inter 2	.22	1,72	<.6378
Treatment	.77	2,71	<.4664	Inter 1	.02	1,72	<.8991
				Inter 2	1.44	1,72	<.2339
G x A	4.20	4,142	<.0031*	Inter 1	3.22	2,72	<.0458
				Inter 2	3.97	2,72	<.0232*
G x S	1.19	4,142	<.3173	Inter 1	1.96	2,72	<.1480
				Inter 2	1.01	2,72	<.3695
G x T	.24	4,142	<.9130	Inter 1	.23	2,72	<.7981
				Inter 2	.31	2,72	<.7318

*Significant at the indicated level.
**Inter 1 - P Diff, A Like, N Like-P Like, A Diff, N Diff
**Inter 2 - A diff, N Like-A Like, N Diff

TABLE 7 (continued)

Source	Multivariate Analysis F	df	Probability	Contrast	Univariate Analysis F	df	Probability
A x S	.26	2,71	<.7715	Inter 1	.29	1,72	<.5945
				Inter 2	.06	1,72	<.7998
A x T	1.33	2,71	<.2713	Inter 1	.34	1,72	<.5600
				Inter 2	1.44	1,72	<.2339
S x T	.98	2,71	<.3818	Inter 1	1.96	1,72	<.1657
				Inter 2	.16	1,72	<.6903
G x A x S	.08	4,142	<.9871	Inter 1	.02	2,72	<.9827
				Inter 2	.14	2,72	<.8729
G x A x T	3.16	4,142	<.0160*	Inter 1	.97	2,72	<.3828
				Inter 2	5.89	2,72	<.0043*
G x S x T	.73	4,142	<.5736	Inter 1	1.23	2,72	<.2995
				Inter 2	.45	2,72	<.6370
A x S x T	.18	2,71	<.8379	Inter 1	.00	1,72	<.9798
				Inter 2	.30	1,72	<.5870
G x A x S x T	1.62	4,142	<.1715	Inter 1	1.04	2,72	<.3590
				Inter 2	2.86	2,72	<.0637

the analyses. Table 7 reports the analyses of the interactions between likeness and difference scores for the factors of grade level, achievement level, sex, and method of presentation.

The multivariate analysis of Perceptible, Attribute, and Nominal responses revealed a significant effect due to grade. Univariate *F* statistics were computed for each category combination variable and only the univariate *F* for the P-$\overline{A+N}$ contrast was significant. Figure 1 illustrates the mean scores for each classification category as a function of grade.

The trends in the use of the Perceptible, Attribute, and Nominal categories are readily apparent. The number of perceptible responses decreases with increasing grade. The number of attribute responses increases with increasing grade. The number of nominal responses remains about the same from Grade 5 to Grade 8 and then increases slightly from Grade 8 to Grade 11. The significant P-$\overline{A+N}$ contrast reflects the predicted tendency for students to rely on the Perceptible basis of classification until their cognitive development allows them to deal with objects according to their intrinsic properties. This occurs in the predicted manner as a function of increasing age. The steepest drop in the use of perceptible responses occurs between Grades 5 and 8. This is congruent with Olver and Rigney's findings that *Ss* at about age twelve rely more on intrinsic properties for classification and less on perceptible ones (Bruner, *et al.*, 1966).

The multivariate *F* test for the achievement effect was significant

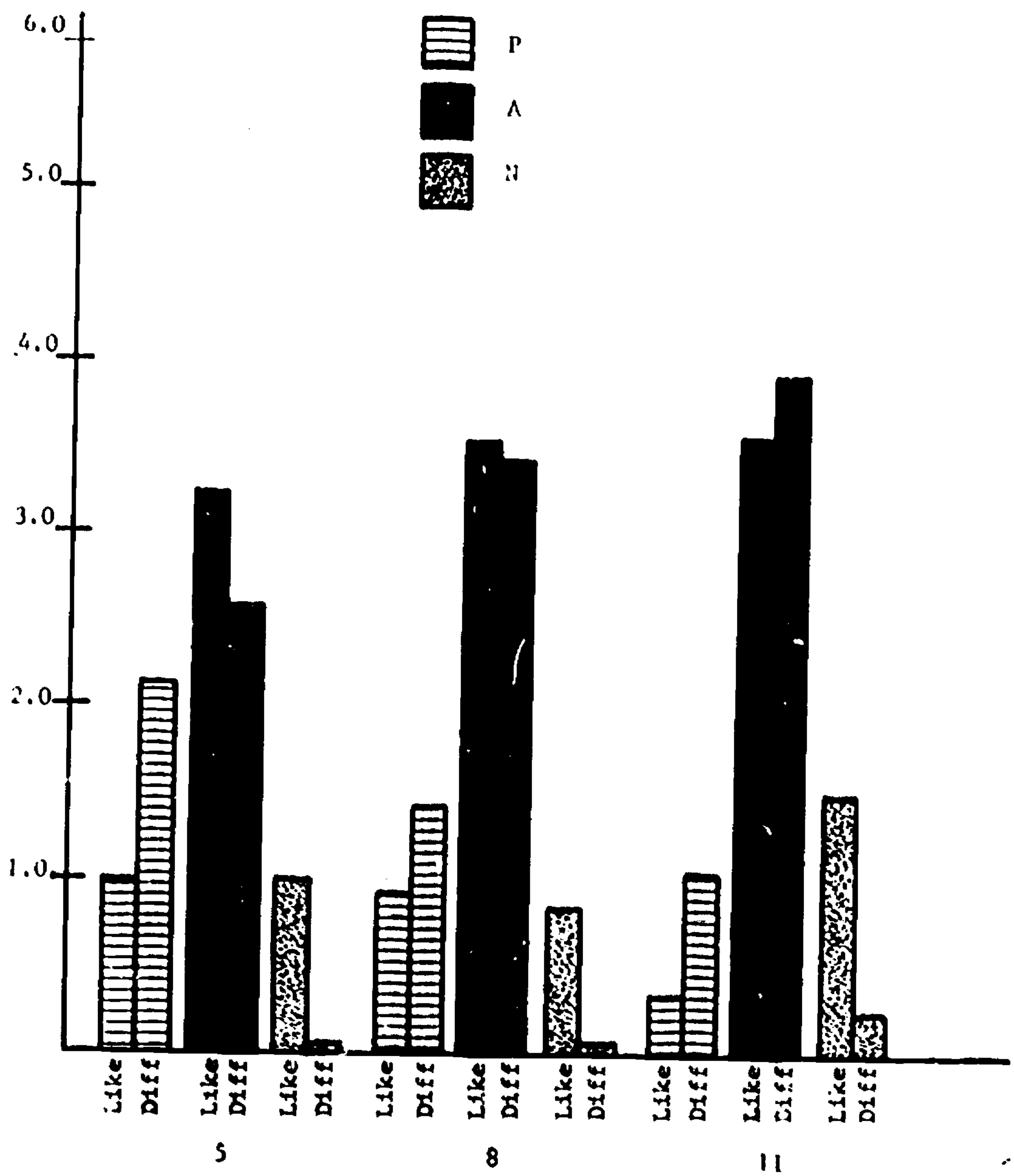

Figure 1. Mean number of initial responses in perceptible, attribute, and nominal categories used by students in grades 5, 8, and 11 on Task I

for both multivariate analyses. The univariate $\underline{F}$ tests for $P\text{-}\overline{A+N}$ and Inter 1 were significant; the univariate $\underline{F}$ tests for A-N and Inter 2 were not significant. Figure 2 shows the mean number of initial responses in each classification category as a function of achievement level. Just as increasing grade level reflected a tendency for $\underline{S}$s to use fewer perceptible and more attribute responses, so does increasing achievement level. While both high and low achievers rely more on the Attribute basis of classification than they do on the Perceptible category, higher achievers give fewer perceptible and more attribute responses than do low achievers. The nominal responses remain at about the same level for both groups.

When asked to describe differences between stimuli, low achievers rely more on Perceptible and less on Attribute categorizations than they do when asked to describe similarities between stimuli. High achievers, however, use the Perceptible and Attribute categories more when asked to describe differences than when asked to describe similarities between stimuli.

Thus, differences occurred in the use of lower-order vs. higher-order bases of classification as a function of achievement level. If Figure 1 can be interpreted to mean that such changes in the categories used occur as a function of increasing age, the result of the achievement factor becomes more interesting. High achieving $\underline{S}$s seem to resemble older $\underline{S}$s in their bases of classification.

There are several possible interpretations of the achievement effect. It is possible, first, that the high-achieving $\underline{S}$s have

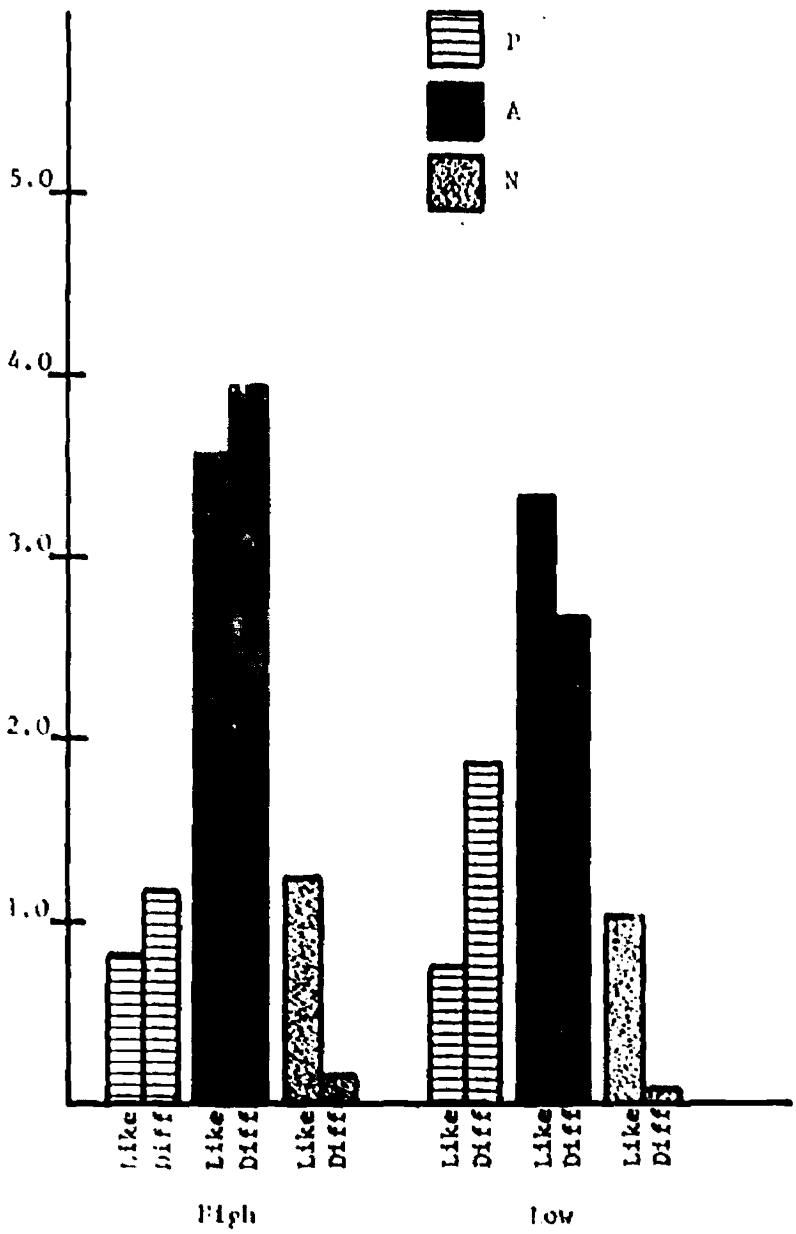

Figure 2. Mean number of initial responses in perceptible, attribute, and nominal categories used by students of high and low achievement on Task I

received different instruction and this is reflected in the classification task. This interpretation was ruled out, however, since no such differences occurred in the sample tested. It then becomes possible to interpret the result as indicating that performance on the classification task might signal a difference in the level of cognitive development. If cognitive ability does develop more slowly in some children as compared to others in their age group, this difference might be reflected on the classification task as a significant difference on this achievement factor. The finding of Levy and Cuddy (1956) that underachievers develop more slowly than normal achievers would tend to support this second interpretation that the cognitive growth of low achievers appears to develop more slowly than that of high achievers.

Both multivariate analyses showed a significant grade x achievement level interaction. The univariate Fs for A-N and Inter 2 were also significant. While the main effects for grade and achievement level seemed to reflect a developing ability to use higher-order bases of classification, the significant interaction between grade and achievement suggests the differential use of the higher-order Attribute and Nominal categories. Figure 3 illustrates the interaction of grade and achievement in the Attribute and Nominal classification categories.

Looking at the responses in the Attribute and Nominal categories, it appears that high achievers use attribute responses more frequently than low achievers except in the fifth grade where the

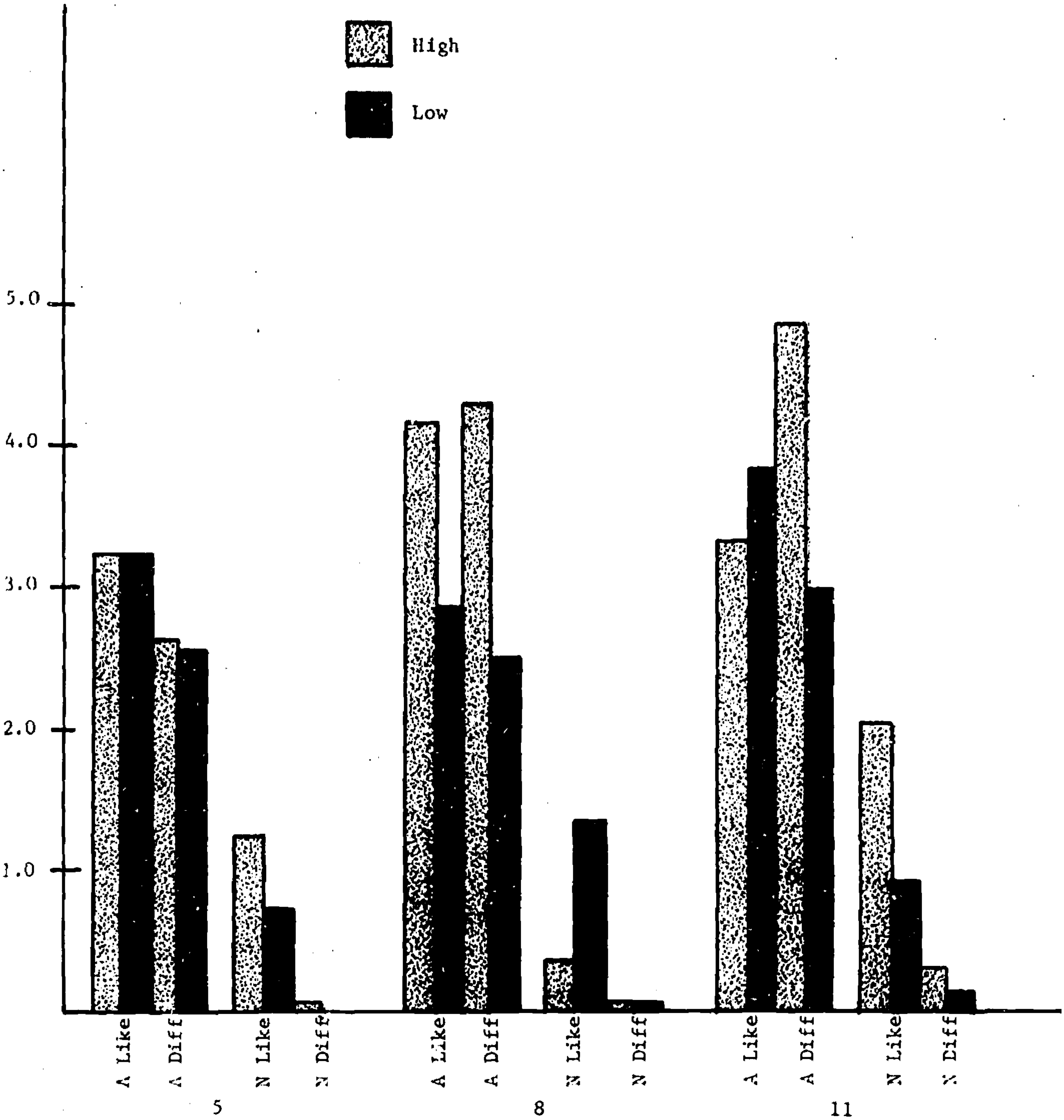

Figure 3. Mean number of initial responses in attribute and nominal categories used by students in each grade x achievement group on Task I

means are about the same. Fifth- and eighth-grade low achievers give about the same number of attribute responses, but the number increases for eleventh-grade low achievers. High achievers, however, are similar in Grades 8 and 11, using more attribute responses than Ss in Grade 5. Thus, fifth- and eighth-grade low achievers resemble each other as do eighth- and eleventh-grade high achievers. The greatest difference between achievement levels in number of attribute responses occurs in the eighth-grade.

In the nominal category, fifth- and eleventh-grade high achievers give more nominal responses than do low achievers, but in the eighth grade, low achievers give more nominal responses than high achievers. Eleventh-grade high achievers use this category more than any other group.

Figure 3 also suggests the pattern of scores which led to the significant grade by achievement interaction for Inter 2. Differences occur in the use of the Nominal category when Ss are asked to describe likenesses and differences between stimuli. Few nominal responses are given when Ss are asked to describe differences between stimuli regardless of grade or achievement level, but when they are asked to describe similarities between stimuli, all students use this category. High achievers in Grades 5 and 11, however, use it more than low achievers in their grade and low achievers in Grade 8 use it more than high achievers in their grade.

In interpreting the grade x achievement interaction, several trends appear worthy of discussion. High achievers increase their use of the Attribute category as they move from fifth to eighth grade and then remain at about the same level through the eleventh grade, while the low achievers do not begin to increase their use of this category until they move from eighth to eleventh grade. This finding supports the speculation that low achievers may shift from perceptible to attribute and nominal bases of classification later than high achievers.

It is at first puzzling, then, to note that high achievers in the eighth grade use the Nominal category less frequently than low achievers. The eighth-grade low achievers, however, may give the concepts a name which groups them together but which is not a superordinate concept name. They may say, for example, that the concepts are all alike because they are all used in arithmetic or because they are all figures. High achievers, on the other hand, may search for intrinsic properties and since they have not yet learned the superordinate concept names give attribute responses. They possibly ignore the option of grouping concepts together with a name which does not really describe the intrinsic values, since they recognize that this is not the name they are looking for. This interpretation is consistent with the conjectures of Friedman (1965) and Tagatz (1967) that children just entering a new stage of development may not handle effectively the new techniques they are developing.

The bases of classification used by Ss in grade x achievement groups when contrasting the likeness and differences between stimuli are similarly interpreted. Again, high achievers give more higher-order responses than low achievers in Grades 5 and 8, regardless of whether they are describing likenesses or differences between stimuli. As they move from eighth to eleventh grade, however, high achievers seem to become more competent in knowing when to selectively apply a superordinate concept name, so that in the eleventh grade they use the Nominal category when asked to describe similarities between stimuli and are able to substitute attribute responses when asked to describe differences.

Low achievers, however, increase in the number of higher-order responses used in the eleventh grade for both conditions. Both the ability to use the Attribute category and the ability to use the Nominal category correctly seem to be developing. Again, the low achievers, however, do not seem to develop this ability as rapidly as high achievers.

The multivariate $\underline{F}$ test for the effect of method of presentation was significant. The univariate $\underline{F}$ test for P-$\overline{\text{A+N}}$ was significant, while the univariate $\underline{F}$ test for A-N was not. Figure 4 illustrates the mean number of initial responses in each classification category as a function of verbal or pictorial method of presentation. By looking at the graph, it is easy to see that the Perceptible category is used to a far greater extent in the pictorial than in the verbal condition while the number of attribute and nominal responses remain about the same for both groups. This difference in the use of the Perceptible category occurs in the predicted manner as a function of the type of symbol used and is consistent with the results of prior research (Davidon, 1952;

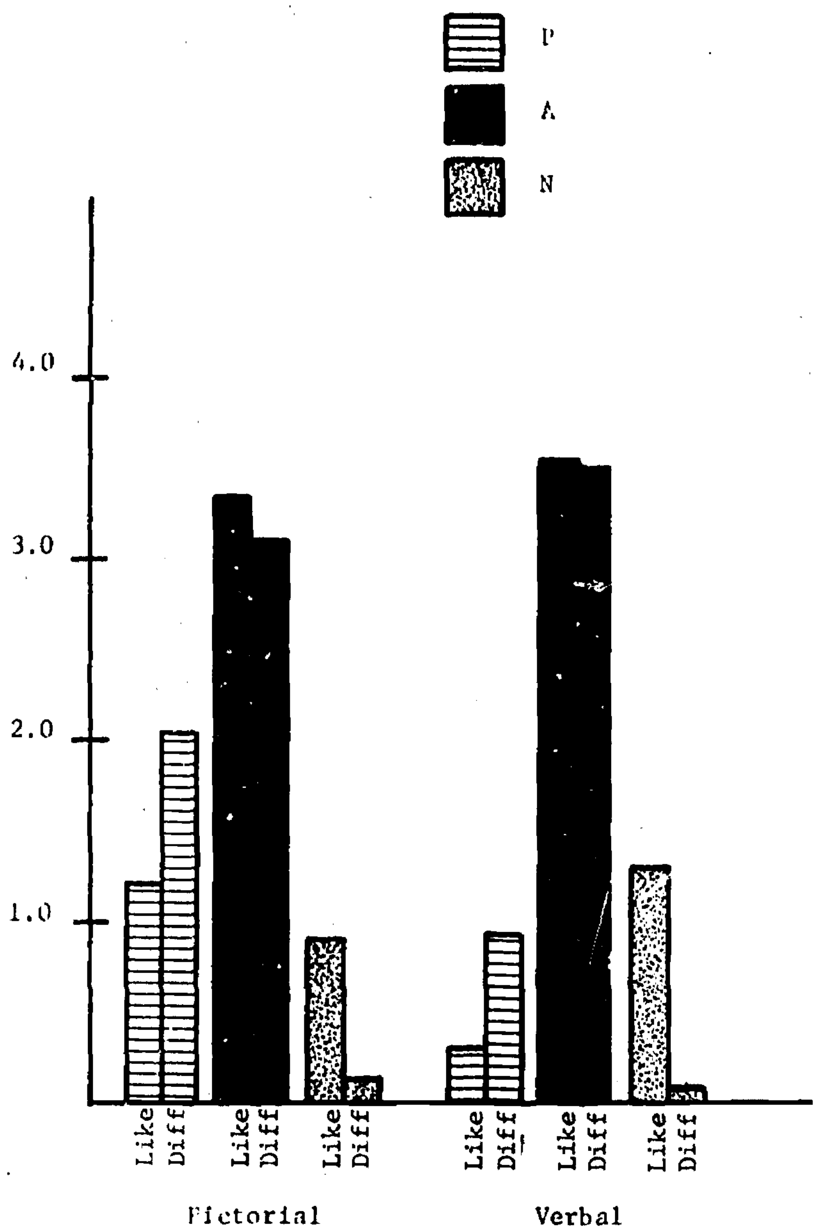

Figure 4. Mean number of initial responses in perceptible, attribute, and nominal categories used by students in pictorial and verbal treatment groups on Task I

Rigney, 1962), which indicated that pictorial stimuli tend to elicit responses based on perceptual cues.

The final significant finding in the multivariate analyses of variance for Task I is a three-way interaction between grade, achievement, and treatment. Multivariate F tests were significant in both analyses for this interaction, with the univariate F tests indicating that the significance lay in the A-N and Inter 2 comparisons. In Tables 8 and 9 are shown the means involved in these comparisons.

Looking first at Table 8, which shows the means for the A-N categories, it can be seen that the interaction is again primarily due to the behavior of the Ss in the eighth grade. In the Attribute category, fifth graders do not differ in the number of attribute responses given as a function of achievement level or treatment group. Eighth-grade low achievers, however, give fewer attribute responses than high achievers regardless of treatment group and eleventh-grade Ss give fewer attribute responses if they are low achievers presented with pictorial stimuli. In the Nominal category, fifth- and eleventh-grade Ss give more nominal responses in the high achievement, verbal treatment group than any other group. The most nominal responses in the eighth grade are given by low achievers in the verbal treatment group.

The interpretation of the findings in the Nominal category are again consistent with the literature on method of presentation. When names are used as stimuli, it is more likely that names will be given as responses than when pictures are used as stimuli

TABLE 8

Mean Number of Initial Responses in Attribute and Nominal Categories Used by Students in Grade x Achievement x Treatment Groups on Task I

Grade	Category	High-Pictorial	High-Verbal	Low-Pictorial	Low-Verbal
5	Attribute	3.06	2.81	2.62	3.13
	Nominal	.5	.81	.31	.43
8	Attribute	3.62	4.75	3.31	2.56
	Nominal	.43	.37	.5	.93
11	Attribute	4.19	4.0	2.87	3.94
	Nominal	.81	1.56	1.0	.06

TABLE 9

Mean Number of Initial Responses in Attribute and Nominal Categories Contrasting Likeness and Difference Scores Used by Students in Grade x Achievement x Treatment Groups on Task I

Grade	Category	High-Pl	High-V	Low-P	Low-V
5	A Like	3.62	2.87	3.0	3.5
	A Diff	2.50	2.75	2.25	2.87
	N Like	.87	1.62	.62	.87
	N Diff	.12	0	0	0
8	A Like	3.37	5.0	3.37	2.37
	A Diff	2.87	4.5	12.25	2.75
	N Like	.87	.62	.87	1.87
	N Diff	0	.12	.12	0
11	A Like	3.75	2.87	2.87	4.75
	A Diff	4.62	5.12	2.87	3.12
	N Like	1.25	2.87	1.75	.12
	N Diff	.37	.25	.25	0

(Runquist & Hutt, 1961).

Table 9 breaks down the interaction further by examining the differences which occur when likeness and difference responses are considered. It is obvious that the findings in the Nominal category discussed above are due to nominal responses given when likenesses between stimuli are to be described, since all groups give a negligible number of nominal responses when differences between stimuli are described.

In examining the results of the analyses of the bases of classification used by students on Task I, it seems that several significant trends have appeared. Decreasing use of the Perceptible category occurred with increasing grade. Perceptible bases of classification were used more frequently when pictures were used as stimuli than when words were used. These are replications of the results found in the Olver and Rigney studies (Bruner, et al., 1966).

The most striking result, however, lies in the effect of achievement level on the bases of classification employed. It appears throughout all the significant results when achievement is involved that low achievers in the eighth grade seem to respond similarly to high achievers in the fifth grade while high achievers in the eighth grade respond similarly to low achievers in the eleventh grade.

Subject-Fiat Response Analysis

The next analysis which was carried out on the Task I data involved the Subject-Fiat category. Subject-Fiat responses reflect an inability to use the Perceptible, Attribute, or Nominal bases of classification. Therefore, the number of initial responses in this category is an index of the relative difficulty of describing similarities and differences between stimuli.

The results of the univariate analysis of the difference score, S Like-S Diff, are presented in Table 10. There were two significant effects in this analysis, method of presentation, and the three-way interaction of achievement, sex, and treatment.

The means on S Like and S Diff for each treatment group are shown in Figure 5. It appears that S Like and S Diff responses occur with about equal frequency when pictorial stimuli are used. When verbal stimuli are used, however, more S Diff than S Like responses are given. When pictures are used as stimuli, there are perceptual cues available for responding but when words are presented this aid is removed. Subjects are then forced to rely more on their knowledge of the intrinsic properties of the concepts, making the task more difficult.

The second significant result in this analysis was a three-way interaction between achievement level, sex, and treatment. The means for the interaction are shown in Table 11. When asked to describe similarities between stimuli, high achievers give about the same number of fiat responses regardless of sex or treatment

TABLE 10

Univariate Analysis of Variance of Initial Responses on Task I in the Subject-Fiat Category Contrasting Likeness and Difference Subtasks

Source	F	df	Probability
Grade	.32	2,72	<.7272
Achievement	.007	1,72	<.9315
Sex	3.28	1,72	<.0742
Treatment	4.65	1,72	<.0344*
G x A	1.71	2,72	<.1891
G x S	.69	2,72	<.5039
G x T	.23	2,72	<.7946
A x S	3.28	1,72	<.0742
A x T	.91	1,72	<.3458
S x T	.007	1,72	<.9315
G x A x S	.20	2,72	<.8184
G x A x T	.36	2,72	<.6957
G x S x T	.007	2,72	<.9926
A x S x T	4.65	1,72	<.0344*
G x A x S x T	.23	2,72	

*Significant at the indicated level.

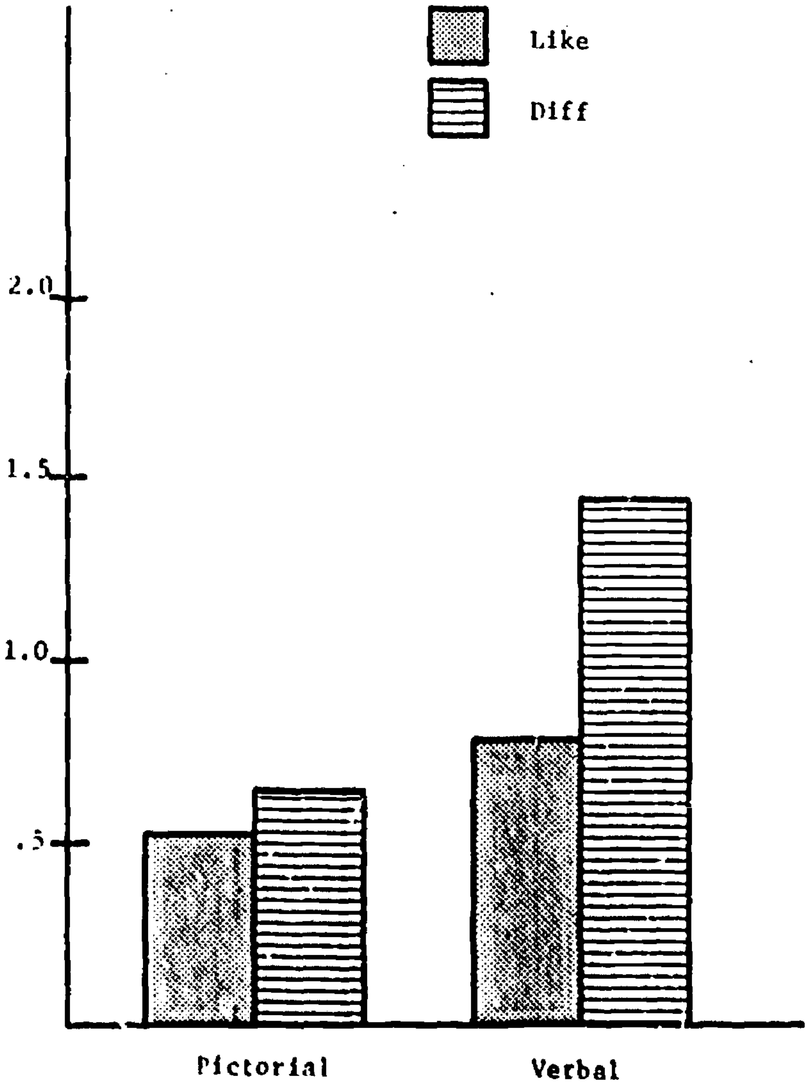

Figure 5. Mean number of initial responses in the subject-flat category used by students in pictorial and verbal treatment groups on Task I

TABLE 11

Mean Number of Initial Responses in the Subject-Fiat Category Used by Students in Achievement x Sex x Treatment Groups on Task I

	S Like	S Diff
High Achievement Males Pictorial	.50	.75
High Achievement Males Verbal	.17	.67
High Achievement Females Pictorial	.42	.17
High Achievement Females Verbal	.42	1.42
Low Achievement Males Pictorial	.75	1.17
Low Achievement Males Verbal	.58	1.83
Low Achievement Females Pictorial	.50	.58
Low Achievement Females Verbal	2.0	1.83

group, although boys in the verbal group seem to have the least difficulty in comparing the concepts. Low achieving girls, in the verbal group, however, give more flat responses than any other low achieving group. All low achievers use this category more extensively than high achievers. This finding concerning the low achieving girls can probably again be attributed to the fact that with perceptual cues missing, the Ss must rely on their knowledge of the intrinsic properties of the concepts and girls are not strong in mathematical reasoning ability (Tyler, 1965b).

When high achievers are asked to describe differences between stimuli, girls in the pictorial condition have the least difficulty, probably due to their superior verbal ability (Terman & Tyler, 1954). Girls in the verbal group use the Subject-Flat category more than the other high achieving groups. This again apparently reflects a sex difference in the mathematical reasoning ability.

In Task I, then, it appears to be more difficult to describe differences between stimuli than it is to describe similarities, a difficulty that is compounded when verbal stimuli are used.

Percentage of Correct Classification

Finally, for each S, the percentage of total correct classifications was tabulated. The mean percentage of correct classifications as a function of grade, achievement level, sex, and method of presentation are shown in Table 12. The results of the analysis of variance of percent of total responses which were correct on Task I is shown in Table 13. Although the means for grades 5, 8,

TABLE 12

Means and Standard Deviations of the Percentage of Total Correct Responses on Task I

Grade	Achievement	Sex	Pictorial	Verbal
5	High	Male	94.5 (6.81)	93.75 (9.46)
		Female	95.5 (5.45)	93.25 (11.59
	Low	Male	88.75 (17.04)	90.25 (4.35)
		Female	86.0 (5.23)	87.5 (9.85)
GRADE MEAN			90.19	91.19
8	High	Male	96.0 (5.23)	97.75 (2.63)
		Female	98.75 (2.5)	97.0 (4.24)
	Low	Male	93.0 (8.45)	86.75 (6.62)
		Female	97.0 (6.0)	84.75 (10.18)
GRADE MEAN			96.19	91.56
11	High	Male	100.0 (0)	96.0 (8.0)
		Female	100.0 (0)	94.5 (4.2)
	Low	Male	97.75 (2.63)	89.0 (4.55)
		Female	89.75 (10.4)	93.25 (5.74
GRADE MEAN			96.81	93.19

Note.-Standard deviations are given in parentheses.

TABLE 13

Univariate Analysis of Variance for Percent of Total Correct Responses on Task I

Source	F	df	Probability
Grade	2.3021	2,72	.1074
Achievement	16.5423	1,72	.0002*
Sex	.1204	1,72	.7296
Treatment	3.4085	1,72	.0690
G x A	.1216	2,72	.8857
G x S	.2569	2,72	.7742
G x T	.8846	2,72	.4174
A x S	.2098	1,72	.6483
A x T	.2098	1,72	.6483
S x T	.0002	1,72	.9890
G x A x S	.0850	2,72	.9187
G x A x T	1.7279	2,72	.1850
G x S x T	.9621	2,72	.3870
A x S x T	.5012	1,72	.4813
G x A x S x T	.6630	2,72	.5184

*Significant at the indicated level.

and 11 did show an increase in percentage of correct responses with increasing grade, they were not significantly different from each other at the .05 level. The only significant finding was the univariate F test for the achievement level factor. The mean percent correct for the high achievement group was 96.42% and the mean percent correct for the low achievement group was 90.31%.

When all responses were considered, high achievers gave a higher percentage of correct classifications than did low achievers. This suggests that high achievers were secure in their judgments regarding similarities and differences between the geometric figure, while low achievers may have been searching for bases by which to classify the figures.

Results and Discussion - Task II

For each S on Task II, the number of initial responses in each classification category was tabulated. Task II consisted of free-sorting geometric pictures and Ss were asked to make and explain seven sorts. The mean number of initial responses in each category as a function of grade level, achievement level, sex, and method of presentation are shown in Table 14.

The Perceptible, Attribute, and Nominal categories were linearly combined into two orthogonal contrasts which served as the dependent variables in the multivariate analysis of variance. As in Task I, the first dependent variable was the contrast between the lower-order Perceptible and higher-order Attribute and Nominal categories. The variable was formed by taking the average number of attribute

Table 14

Means and Standard Deviations of the Number of Initial Responses in Perceptible, Attribute, and Nominal Categories as a Function of Grade, Achievement Level, Sex, and Method of Presentation for Task II

GRADE	CONDITION	PICTORIAL			VERBAL		
		P	A	N	P	A	N
5	High male	3.25 (2.63)	.5 (.57)	3.25 (2.36)	.75 (.96)	2.25 (1.22)	4.0 (1.82)
	High female	1.0 (.82)	1.75 (1.26)	4.25 (1.26)	2.75 (1.22)	1.0 (1.41)	3.25 (.96)
	Low male	3.0 (1.22)	1.75 (1.26)	2.25 (1.71)	1.5 (.58)	1.5 (1.29)	4.0 (1.82)
	Low female	2.75 (1.5)	2.0 (2.83)	2.25 (2.22)	3.5 (3.11)	1.5 (1.29)	2.0 (2.83)
GRADE MEAN		2.5	1.5	3.0	2.12	1.56	3.31
8	High male	1.25 (1.89)	1.0 (.82)	4.75 (1.5)	0 (0)	1.5 (2.38)	5.5 (2.38)
	High female	0 (0)	3.5 (1.73)	3.5 (1.73)	.25 (.50)	.5 (.58)	6.25 (.50)
	Low male	2.0 (2.0)	2.75 (2.22)	3.25 (1.26)	3.75 (1.5)	0 (0)	3.25 (1.5)
	Low femalu	3.0 (1.41)	.25 (.50)	3.75 (1.26)	2.25 (.96)	.5 (.58)	4.25 (1.26)
GRADE MEAN		1.56	1.87	3.56	1.56	.62	4.81

GRADE	CONDITION	PICTORIAL			VERBAL		
		P	A	N	P	A	N
11	High male	.5 (.58)	3.0 (2.16)	3.5 (1.73)	.25 (.5)	.5 (1.0)	6.25 (.96)
	High female	1.0 (1.41)	1.25 (1.26)	4.75 (2.63)	.5 (.58)	.5 (1.0)	6.0 (1.41)
	Low male	.75 (1.5)	.25 (.5)	6.0 (1.41)	1.75 (1.5)	1.50 (1.29)	3.75 (2.06)
	Low female	2.25 (1.50)	1.0 (.82)	3.75 (.96)	.25 (.50)	2.0 (1.41)	4.75 (1.50)
GRADE MEAN		1.12	1.38	4.5	.68	1.12	5.19

Note.- Standard deviations are given in parentheses.

and nominal responses and subtracting it from the number of perceptible responses (P-$\overline{A+N}$). The other dependent variable was the difference between the higher-order Attribute and Nominal categories (A-N). The use of these contrasts allowed the testing of interactions of the bases of classification with the independent variables of grade level, achievement level, sex, and method of presentation on Task I. Method of presentation was included as a variable since the second task occurred directly after the first one. Thus, the nature of the stimuli used to present the concepts on Task I might affect the bases of classification on Task II.

The multivariate analysis of variance was carried out using Finn's (1968) computer program. The results of the analysis are found in Table 15. Again, the significance level was set at .05 for the multivariate $\underline{F}$ test and .025 for the univariate $\underline{F}$ tests.

The multivariate $\underline{F}$ for the grade effect was significant. The univariate $\underline{F}$ tests for the P-$\overline{A+N}$ and the A-N contrasts were both significant. Figure 6 illustrates the mean scores for each classification category as a function of grade. The trends for both significant contrasts are readily apparent. As grade increases, the use of the Perceptible category decreases while the use of the higher-order bases of classification increases. In the contrast comparing the higher-order bases of classification, it can be seen that while the use of the Attribute category decreases slightly from Grade 5 to Grade 8 and then remains the same at Grade 11, the use of the Nominal category increases with increasing grade. These results replicate the findings in the Rigney

Table 15

Multivariate and Univariate Analyses of Variance of Initial Responses on Task II Contrasting Classification Categories

	MULTIVARIATE ANALYSIS			UNIVARIATE ANALYSIS			
Source	F	df	Probability	Contrast	F	df	Probability
Grade	4.37	4,142	<.0024*	P-AN	7.14	2,72	<.0015*
				A-N	4.10	2,72	<.0206*
Achievement	8.85	2,71	<.0004*	P-AN	17.47	1,72	<.0001*
				A-N	2.46	1,72	<.1215
Sex	.03	2,71	<.9677	P-AN	.04	1,72	<.8378
				A-N	.01	1,72	<.9133
Treatment	2.38	2,71	<.1003	P-AN	.79	1,72	<.3761
				A-N	4.62	1,72	<.0350
G x A	1.79	4,142	<.1348	P-AN	3.30	2,72	<.0426
				A-N	.22	2,72	<.7996
G x S	.36	4,142	<.8368	P-AN	.55	2,72	<.5798
				A-N	.32	2,72	<.7523
G x T	.90	4,142	<.4673	P-AN	.20	2,72	<.81[illegible]
				A-N	1.36	2,72	<.2643

Table 15 (continued)

	MULTIVARIATE ANALYSIS			UNIVARIATE ANALYSIS			
Source	F	df	Probability	Contrast	F	df	Probability
A x S	.12	2,71	<.8900	P-AN	.23	1,72	<.6330
				A-N	.03	1,72	<.8560
A x T	.92	2,71	<.4049	P-AN	.23	1,72	<.6330
				A-N	1.82	1,72	<.1818
S x T	.24	2,71	<.7888	P-AN	.38	1,72	<.5394
				A-N	.03	1,72	<.8560
G x A x S	1.49	4,142	<.2098	P-AN	.43	2,72	<.6540
				A-N	2.41	2,72	<.0973
G x A x T	1.90	4,142	<.1146	P-AN	.34	2,72	<.7110
				A-N	3.29	2,72	<.0429
G x S x T	2.86	4,142	<.0256*	P-AN	5.87	2,72	<.0044*
				A-N	.14	2,72	<.8655
A x S x T	3.58	2,71	<.0330*	P-AN	5.75	1,72	<.0191*
				A-N	.48	1,72	<.4910
G x A x S x T	2.23	4,142	<.0685	P-AN	.23	2,72	<.7951
				A-N	3.99	2,72	<.0227

* Significant at the indicated level

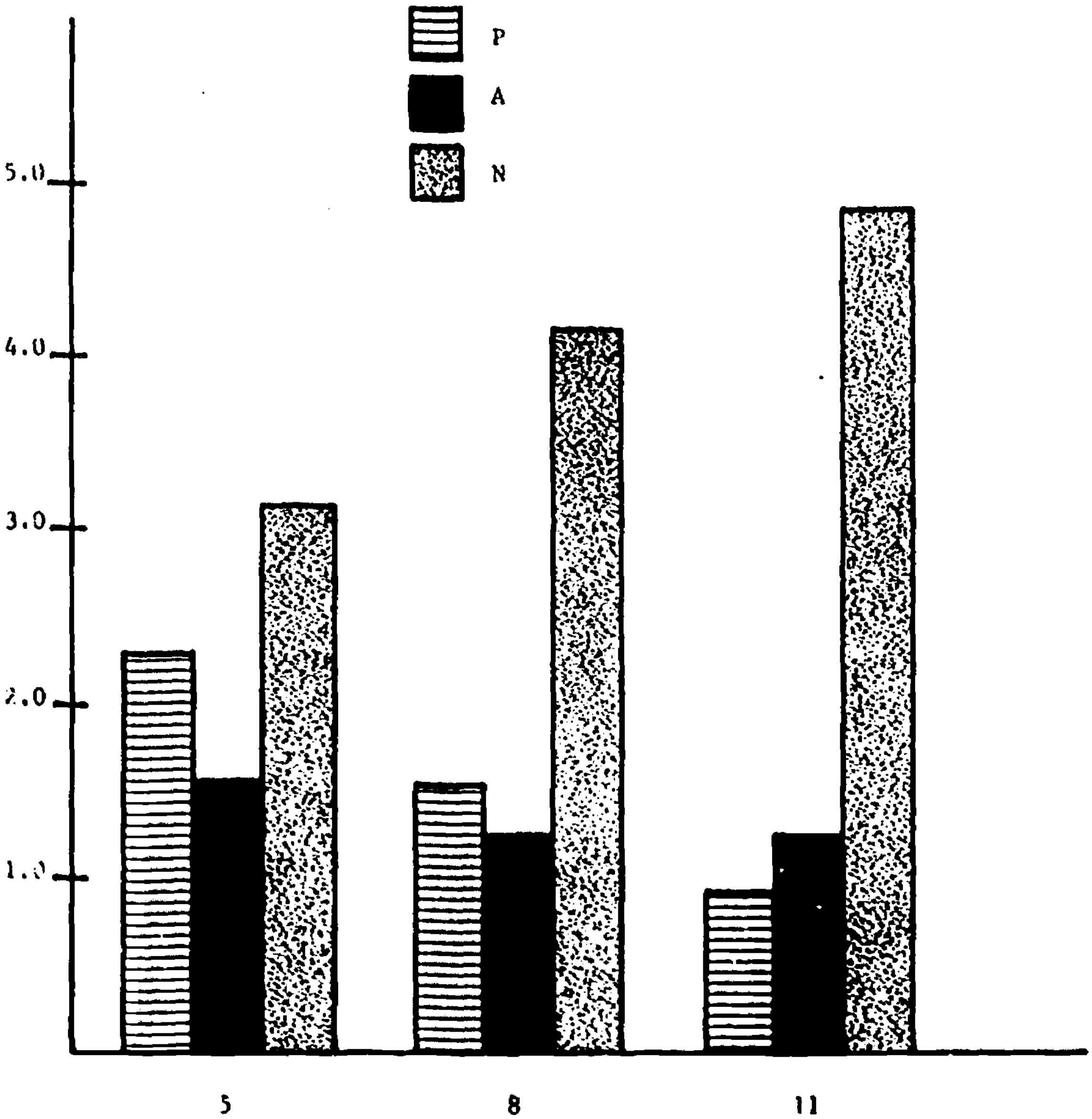

Figure 6. Mean number of initial responses in perceptible, attribute, and nominal categories used by students in grades 5, 8, and 11 on Task II

study. When pictures are used in a free-sort task, the Nominal category is used more frequently than any other higher-order basis of classification.

There was also a significant effect due to achievement level. The multivariate $\underline{F}$ was significant and the univariate $\underline{F}$ indicated that the significance lay in the $P-\overline{A+N}$ contrast. The means for the bases of classification by achievement level are found in Figure 7. High achievers use fewer perceptible and more attribute and nominal responses that do low achievers. Apparently, low achievers depend on perceptual cues more frequently than high achievers.

Two three-way interactions were also significant. The first was the significant interaction between grade, sex, and treatment groups and the second was the significant interaction between achievement, sex, and treatment groups. In both cases, the univariate $\underline{F}$ tests indicated that the significance was in the $P-\overline{A+N}$ contrast.

Table 16 lists the means involved in the grade x sex x treatment interaction. Fifth-grade boys who had been in the pictorial treatment group and fifth-grade girls who had been in the verbal group on Task I used the Perceptible basis of classification more than the Attribute and Nominal bases in explaining how the groups they had formed were alike while all the other groups used more attribute and nominal responses than they did perceptible ones.

The effect of treatment group on Task I is clarified somewhat by looking at the means for the significant achievement x sex x

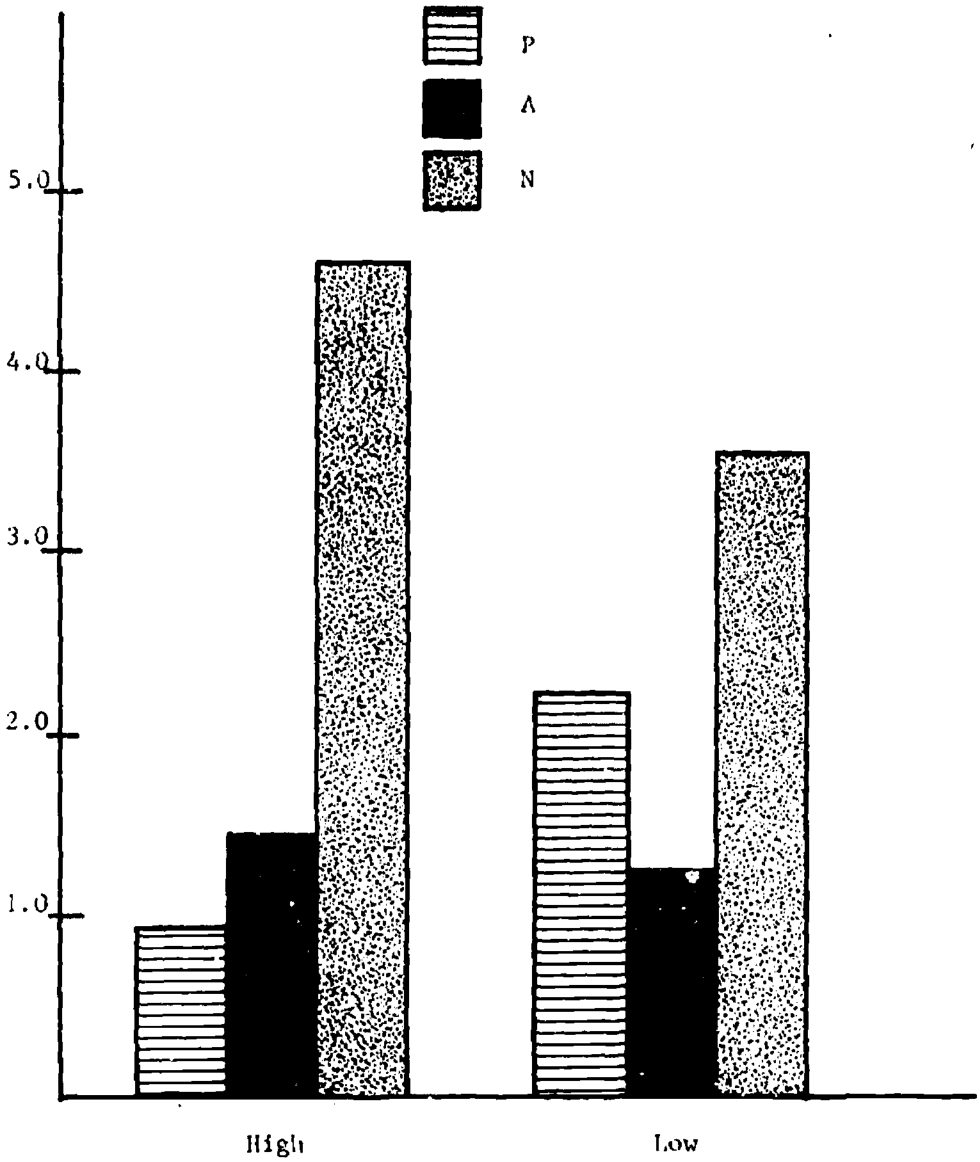

Figure 7. Mean number of initial responses in perceptible, attribute, and nominal categories used by students of high and low achievement on Task II

Table 16

Mean Number of Initial Responses in Perceptible, Attribute, and Nominal Categories
Used by Students in Grade x Sex x Treatment Groups on Task II

Grade	Category	Boys-Pictorial	Boys-Verbal	Girls-Pictorial	Girls-Verbal
5	P	3.125	1.12	1.87	3.125
	A+N	1.94	2.93	2.56	1.94
8	P	1.62	1.87	1.5	1.25
	A+N	2.69	2.56	2.75	2.87
11	P	.62	1.00	1.62	.37
	A+N	3.19	3.00	2.69	3.31

treatment interaction on Task II. The means involved are listed in Table 17. Low achievers again use more perceptible classifications than high achievers in all conditions. High-achieving boys who had received words as stimuli on Task I used practically no perceptible responses on Task II and were able to continue relying on the intrinsic properties of the concepts. Low-achieving boys, however, used a much greater number of perceptible responses, again apparently taking the pictorial presentation on Task II as a cue to revert to the use of lower-order classification.

High-achieving girls in the pictorial group on Task I were able to ignore the use of lower-order responses and use the Attribute and Nominal categories, while low-achieving girls were not and thus used more perceptible responses than attribute and nominal responses. Thus, it appears that the treatment group to which high achievers were assigned on Task I does not affect their performance on Task II but that treatment group does affect the performance of low achievers, either by giving them a set to maintain or by freeing them from a rigorous task by allowing the return to a lower-order basis of classification.

Thus, whether Ss are given a fixed-sequence or free-sort task, they move from reliance on perceptual cues to classification on the basis of intrinsic properties of the concepts as a function of both grade and achievement levels. Moreover, there appears to be greater transfer from Task I to Task II for younger Ss and low-achieving Ss than for older Ss and high-achieving Ss.

A univariate analysis of variance of percentage of total

Table 17

Mean Number of Initial Responses in Perceptible, Attribute, and Nominal Categories Used by Students in Achievement x Sex x Treatment Groups on Task II

Achievement Level	Category	Boys-Pictorial	Boys Verbal	Girls Pictorial	Girls Verbal
High	P	1.6	.33	.66	1.16
	$\overline{A+N}$	2.67	3.33	3.16	2.91
Low	P	1.91	2.33	2.66	2.0
	$\overline{A+N}$	2.54	2.33	2.16	2.5

correct responses was also carried out for Task II. The mean percentages of correct responses are shown in Table 18. The results of the analysis of variance are shown in Table 19. Although percent correct did increase with increasing grade, the effect was not significant. This is to be expected. Since in Task II students decide for themselves what groups of cards to place together, it would be surprising only if they were unable to correctly give the reason which prompted them to select the cards in the first place.

Before drawing conclusions and discussing the implications of the results of the experiment, it is valuable to compare the findings of Task I with those of Task II.

Comparison of Tasks I and II

Since grade level was significant as a main effect in the analysis of both tasks, it can be stated that increasing age leads to the development of the ability to use higher-order bases of classification regardless of whether stimuli are presented in a fixed-order or in a free-sort manner. This is a direct replication of the findings reported by Bruner, Olver, and Greenfield (1966).

Furthermore, the greatest number of perceptible responses was given by Ss in the fifth grade with Ss in grades 8 and 11 using about the same number of these lower-order responses on both tasks. Similar results in the two tasks are again found on the achievement level factor. On both tasks, low-achieving Ss use the Perceptible category significantly more often than high-achieving Ss.

Table 18

Means and Standard Deviations of the Percentage of Total Correct Responses on Task II

GRADE	ACHIEVEMENT	SEX	PICTORIAL	VERBAL
5	High	Male	88.75 (15.56)	95.0 (6.0)
		Female	95.0 (10.0)	93.0 (8.44)
	Low	Male	89.75 (13.72)	80.0 (17.21)
		Female	92.5 (9.0)	89.75 (14.15)
		GRADE MEAN	91.44	89.44
8	High	Male	93.75 (7.32)	97.0 (6.0)
		Female	97.5 (5.0)	88.5 (9.61)
	Low	Male	96.5 (7.0)	93.0 (8.08)
		Female	93.0 (8.08)	82.75 (21.37)
		GRADE MEAN	95.19	90.31
11	High	Male	97.5 (5.0)	100.0 (0)
		Female	100.0 (0)	95.0 (5.77)
	Low	Male	96.5 (7.0)	88.75 (10.44)
		Female	93.0 (8.08)	100.0 (0)
		GRADE MEAN	96.75	95.94

Note.- Standard deviations are given in parentheses.

Table 19

Univariate Analysis of Variance for Per Cent of Total Correct Responses on Task II

Source	F	df	Probability
Grade	2.879	2,72	.0627
Achievement	3.5386	1,72	.0640
Sex	.0209	1,72	.8854
Treatment	1.6426	1,72	.2041
G x A	.0905	2,72	.9136
G x S	1.657	2,72	.1979
G x T	.3552	2,72	.7023
A x S	.1543	1,72	.6957
A x T	.9042	1,72	.3449
S x T	.2889	1,72	.5927
G x A x S	.5744	2,72	.5626
G x A x T	.4392	2,72	.6463
G x S x T	.9199	2,72	.4032
A x S x T	3.1605	1,72	.0797
G x A x S x T	.3629	2,72	.697

While treatment had a significant effect on the basis of classification used on Task I, with Ss receiving pictorial stimuli giving more perceptible responses, treatment was not a significant factor on Task II. This was a puzzling finding. It had been expected that Ss who received the verbal presentation on Task I would respond with more nominal responses on Task II than Ss who had received the pictorial presentation since the verbal presentation Ss would be able to apply the concept labels they had been shown earlier. No student in the fifth grade had known the meaning of the word "rhombus" and yet on Task II many of them would group a set of cards and label them as "rhombuses." Clearly, this was a transfer effect from their exposure to the concept name on Task I.

What might have occurred was that Ss would sort a group of cards and give their "best" answer first, then later apply the concept label they had learned on Task I. Thus, transfer effects might have occurred which were not apparent in the analysis of initial responses. When the results of the total response analysis were examined, this was found to be the case.

The mean proportion of nominal responses given by Ss in the pictorial treatment group on Task I when asked to explain their free-sorts on Task II was .48 and the mean proportion of nominal responses given by Ss in the verbal treatment group was .58. The comparable initial response means were 3.68 for Ss in the pictorial group and 4.43 for Ss in the verbal group. Subjects who were shown words on Task I gave a greater proportion of nominal responses on

Task II than Ss who were shown pictures on Task I. Apparently, there is an effect in the number of nominal responses given due to previous exposure to the concept names, but it does not appear until the student has first given an answer he is more certain is correct.

The most striking difference between the tasks appears in the differential use of the higher-order, Attribute and Nominal, bases of classification. Both attribute and nominal responses are considered to be higher-order responses since they deal with classifying objects on the basis of their intrinsic properties, either by describing the attributes which define the concept or by giving the concepts a label which denotes the S's understanding of the hierarchical order of the concepts.

On Task I, the use of attribute responses far outnumbers the use of nominal responses while, conversely, on Task II more nominal than attribute responses are given. This is a replication of the Rigney study reported in Bruner, Olver, and Greenfield (1966). Rigney found that in the pictorial free-sort task, the Nominal basis of classification becomes an alternative to the Functional Intrinsic basis found in the fixed-order, verbal presentation task carried out by Olver. Since the Attribute basis for this experiment was equated with the Functional basis used in the Olver and Rigney studies as a higher-order response category, the results are congruent. It appears, however, that the effect is not due to the verbal or pictorial method of presentation, as Rigney hypothesized, since Task I used both methods of presentation and still found that attribute responses outnumbered nominal responses. It seems to be due, rather, to the type of task imposed on the Ss. Thus, in a free-sort task, the greatest change in classifying occurs in increasing use of the Nominal basis of classification.

Finally, the results of the analyses on percentage of total correct responses on Tasks I and II should be mentioned. On both tasks, the trend for percentage of correct responses to increase with increasing grade level did appear, although it was not a significant difference. This was probably due to the fact that the Ss in all groups gave a remarkably high percentage of correct responses.

It was encouraging to find no significant effects in the analysis of the percentage of correct responses on Task II, since it would have been difficult to understand why Ss could not give a correct label to groups of cards they had themselves selected on some predetermined basis. The fact that they did give correct labels in all conditions attests to the fact that they took the task seriously and were not merely selecting cards at random and then attempting to justify their selections later.

When cards are presented in a fixed-order, however, as in Task I, it is apparently more difficult to describe the similarities and differences between stimuli. This leads Ss to give reasons which are judged to be incorrect. Here, however, the fact that they did try to give a classification, even if it was an incorrect one, rather than merely giving a flat response can be interpreted as evidence of their acceptance of the task as a meaningful one.